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ABSTRACT

The Tennessee Valley Authority initiated and funded a 2-year study that examined the use of interactive instructional videodiscs in a rural school environment. The purpose of this project was to evaluate the effects of several specific videodisc programs on student learning and academic achievement. Videodisc courseware in mathematics and science instruction, a video encyclopedia database, and a counseling program were placed in a small rural K-12 school in east Tennessee. Teachers in the school were trained in the use of the videodisc medium as well as with the specific videodisc programs they used. Data on student academic achievement were gathered from criterion-referenced and standardized tests. Results of the investigation showed that the didactic videodisc programs were effective in teaching the concepts and procedures they were purported to teach. However, there was little evidence that students could apply this knowledge for solving problems; the knowledge remained "inert." This problem of "inert" knowledge is discussed with respect to some recent research that has examined the use of the videodisc medium for creating problem-solving environments that allow students to overcome this problem. Findings from the analysis of student and teacher use of the video encyclopedia showed that a large number of video topics were examined and used for a variety of school assignments. Data are presented in both narrative and tabular formats. Appendices include an overview of videodisc technology as well as the criterion-referenced and applications tests used in the study. (13 references) (Author/DB)

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Prepared for
The Tennessee Valley Authority

by
The Learning Technology Center
Peabody College of Vanderbilt University

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Abstract

The Tennessee Valley Authority initiated and funded a two year study that examined the use of instructional videodiscs in a rural school environment. The purpose of this project was to evaluate the effects of several specific videodisc programs on student learning and achievement. Videodisc courseware in math and science, a video encyclopedia, and a counseling program were placed in a small rural K-12 school in east Tennessee. Teachers in the school were trained in the use of the videodisc medium as well as with the specific videodisc programs they used. Student achievement data in the form of criterion-referenced and standardized tests were gathered. In addition, records of student videodisc use and attendance and dropout data were collected. Results from the two year investigation showed that the didactic videodisc programs were effective in teaching the concepts and procedures they were purported to teach. However, there was little evidence that students could apply this knowledge for solving problems; the knowledge remained "inert". This problem of "inert" knowledge is discussed with respect to some recent research that has examined the use of the videodisc medium for creating problem-solving environments that allow students to overcome the inert knowledge problem. Findings from the analysis of student and teacher use of the video encyclopedia showed that a large number of video topics were examined and used for a variety of school assignments.

An Evaluation of Specific Videodisc Courseware on Student Learning in a Rural School Environment

INTRODUCTION

Poor performance in school achievement has been a national concern for the past two decades. Since the National Assessment of Educational Progress (NAEP) was first implemented, media, parents, and concerned educators have debated potential causes for the low test scores of students in elementary and secondary grades and have searched for ways to remediate the problem.

Under appropriate conditions, all but the most seriously learning handicapped children can learn enough in the elementary grades to serve as a basis for success in the later grades. The recognition of this fact is an essential starting point for a consideration of education for all students. Yet not every child is attaining an adequate level of basic and critical thinking skills. According to the NAEP, almost a quarter of all 17-year-olds in school have a reading level below that required to read simple popular magazines. Add to this percentage the approximate 14 percent of students who have dropped out by age 17 and it becomes apparent that the problem of functional illiteracy in this country is critical.

Although the problems faced by all of America's schools are immense, the problems described above are often exacerbated in America's rural schools. Although the overall number of students completing high school has increased substantially since 1960 in both metropolitan and rural areas, only about 60 percent of the rural population who are now over 25 years of age have completed high school. This represents about a 10 percent gap between metropolitan and rural populations. In addition, the proportion of the adult rural population that completed college in 1980 was about the same as the metropolitan percentage about a decade before -- about one in ten. These residential differences are even more marked for racial minorities.

The current reform movement fueled by the publication of *A Nation at Risk*, has created additional challenges for small, rural schools. The size and isolation of small rural schools have created unique challenges for those trying to provide rural students with educational opportunities. It has been difficult for rural schools to recruit certified teachers in the areas mathematics and science. Add to this more stringent credential requirements and the small numbers of students wanting advanced courses in science and mathematics and the problem is compounded. For example, consider differential credential requirements for teachers of biological sciences and those of physical sciences. Consider also that credential requirements for junior high and senior high school teachers differ, and that the school serves grades 7 through 12. Under such circumstances, the educational challenges grow with each requirement added by educational reforms. The result

of much of this reform is that rural schools are forced to have teachers teach in areas in which they are not certified.

Despite pressing challenges, rural schools can use strategies that mitigate these challenges. One strategy that is gaining recognition and popularity among the Nation's rural schools is the use of technology for the delivery of courses where the demand for the course is low (e.g. physics, chemistry, trigonometry), or where there are no certified teachers in the school. Technologies with promise for ameliorating these problems include the use of telecommunications, computer-based instruction, and videodisc.

Purpose of the Study

The purpose of the current project was to examine the effectiveness of a specific set of videodisc courseware on student achievement in a rural school environment. It should be noted that the media (i.e. videodisc) was not the primary focus of the evaluation. The goal of the evaluation was to determine the effectiveness of the specific instruction since the videodisc is simply a medium for transporting the instructional program. To compare the effects of the videodisc medium on learning one would have to deliver the content of the instruction via several different media such as videotape or closed circuit TV to see if there is any advantage in the videodisc medium itself. While this may be an interesting comparison, the current evaluation was focused on the effects of specific videodisc courseware on student learning.

METHOD

The current project was conducted over a two-year period from September, 1987 to May, 1989. This project was initiated by the Community Economic Development Program of the Tennessee Valley Authority (TVA). All equipment and videodisc courseware used in the project was provided for the participating schools by TVA. In addition, TVA contracted with the Learning Technology Center, Peabody College of Vanderbilt University to conduct an evaluation of the project.

The specific procedures used during Year 1 and Year 2 of the study will be described in subsequent sections of this report. General procedures that were constant during both years of the study follow.

Study Demographics

Morgan County

The study was conducted in Morgan County, Tennessee. Morgan County was selected by the TVA as the research site because the demographics and the educational programs in that county are representative of much of the area served by the Tennessee Valley Authority. Morgan County is located in the northeasterly part of Tennessee as shown in Figure 1.

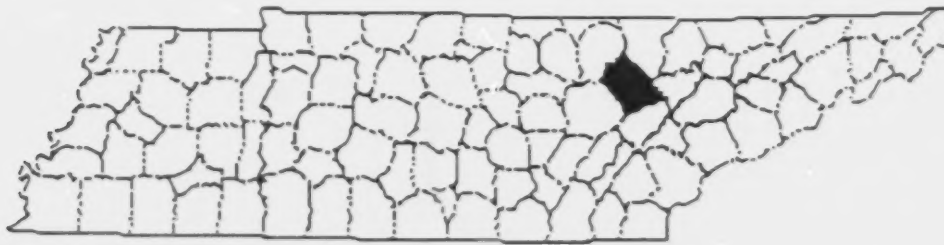


Figure 1. Morgan County

Data from the 1986 U.S. Bureau of Economic Analysis, indicate that the per capita income for Morgan County was \$7,701 while the per capita income for the remainder of the State was \$11,995. Data from the 1980 U.S. Census of the Population indicate that for all persons 16 - 19 years of age in Morgan county, only 60.7% were enrolled in school. Of the 39.3% not enrolled in school, 19.9% had not graduated from high school. For persons 18-24 years of age in Morgan County, only 63.3% were high school graduates and only 1.1% had four or more years of college.

The demographic data from Morgan County suggests an area that is economically and educationally depressed. This area is similar to many other areas within the geographic area that the Tennessee Valley Authority serves.

School System

At the time of the project, the Morgan County School System had a total enrollment of 3,392 students in grades kindergarten through 12 distributed throughout six schools. Of the six schools in the county, three served students from kindergarten through 12th grade, two served students from kindergarten through 8th grade, and one school served students from 9th through 12th grade. Table 1 shows the demographics of each of these schools.

Insert Table 1 about here

Target Schools

Two schools, Coalfield and Oakdale, were selected for participation in the study. The two schools were selected because of their demographic similarity. Coalfield School was selected as the experimental school and Oakdale School was selected as the contrast school. Both Coalfield and Oakdale schools provided a kindergarten through twelfth grade education. At the time of the study the student enrollment at Coalfield was 516 and Oakdale was 549.

Videodisc Materials

The experimental school, Coalfield was provided with videodisc courseware and players through a grant by the Tennessee Valley Authority. Except for one video program, all of the videodisc courseware packages used in the study were Level 1 programs which required only the use of a videodisc player and hand controller (for a more complete description of the levels of videodisc interactivity see Appendix A.) The one exception, a program called *Pathfinder*, was a Level 3 interactive system that required the use of an Apple IIe computer to control the program.

The contrast school, Oakdale, received no videodisc equipment, training, or courseware during this project and served only as a comparison against which changes in the Coalfield School could be compared. It should be noted that while no attempt was made during this project to equate the instruction in the two schools, the teachers in the contrast school were aware of the objectives and goals of the videodisc programs being used in the experimental school.

The videodisc programs that were used in the study came from several different vendors and covered a variety of topics. Following is a short description of each of the programs.

Core Concepts in Science and Mathematics

Core Concepts in Science and Mathematics published by Systems Impact, Inc., consists of a series of videodisc based minicourses designed to provide group-based instruction using a Level 1 format. The fundamental methodology underlying the *Core Concepts* series can be summarized by six fundamental instructional functions identified by Rosenshine and Stevens (1986), these include:

1. review (check previous day's work and reteach if necessary);
2. present new content/skills;
3. guided student practice (and check understanding);
4. feedback and correctives (and reteach if necessary);
5. independent student practice; and
6. weekly and monthly reviews

All of the *Core Concepts* programs are designed to be used in a group setting with the videodisc player and monitor being placed in front of the class. The entire class watches the monitor, where animated sequences, narration, and still-frame problems provide the teaching. The teacher directs the presentation of the videodisc program through the use of a hand-held remote control device. Each course is divided into 35-minute lessons, and the typical lesson opens with a quiz of important material introduced in the preceding lesson and specified "remediation" if the class does not meet an acceptable criterion of performance on the quiz. Following the quiz is the presentation of new information through animations and questions presented by a narrator to the students. Students respond orally to the prompts by the narrator. The live segments are followed by still-frame problems and by a homework assignment in the workbook. All quizzes, tests, reviews, remediations, and assignments are handled by the video programs. Following is a short description of each of the *Core Concepts* programs used in the project.

Mastering Fractions. This minicourse consists of 35 lessons that covers basic concepts in fractions. The content of the course includes:

- a. discriminating whether fractions are more than, less than, or equal to one;
- b. decoding fractions so they are understandable on the number line or as diagrams;
- c. writing whole numbers and other values as a fraction;
- d. generating equivalent fractions;
- e. ranking fractions by size;
- f. rewriting whole numbers on number lines as fractions;
- g. rewriting fractions as mixed numbers;
- h. simplifying fractions
- i. multiplying fractions by fractions and whole numbers;
- j. adding and subtracting fractions with unlike denominators;
- k. rewriting mixed numbers as fractions; and
- l. dividing fractions.

Mastering Decimals and Percents. This program is intended as a skill-building, pre-algebra video based minicourse that teaches the basic concepts of decimals and percents. The content of the course includes:

- a. reading and writing decimals with tenths, hundredths and thousandths;
- b. adding and subtracting decimals numbers;
- c. multiplying decimal numbers;
- d. dividing to change fractions and mixed numbers into decimals;
- e. dividing decimal numbers;
- f. converting fractions, decimals, percents and whole numbers;
- g. rounding decimal numbers; and
- h. solving simple percent whole problems.

Mastering Ratios. Building on the concepts covered in Mastering Fractions and Mastering Decimals and Percents, this 40 lesson minicourse includes the following:

- a. relationships between equivalent fractions and ratios;
- b. estimating the missing part of a ratio;
- c. translating word problems into ratios; and
- d. solving word problems that include percents and ratios.

Understanding Chemistry and Energy. This program is designed to present fundamental chemistry and energy concepts that are building blocks for a number of other science courses. The minicourse is intended for students who have had no previous exposure to chemistry. The content of the course includes:

- a. atomic structure -- electrons, protons, and neutrons;
- b. elements and compounds;
- c. basic energy concepts;
- d. chemical reactions;
- e. covalent and ionic bonding;
- f. water and hydrogen bonding;
- g. equilibrium;
- h. diffusion;
- i. energy of activation and catalysts;

- j. organic compounds; and
- k. writing simple chemical formulas and equations.

Earth Science. This minicourse presents the basic facts about forces and matter, then applies these concepts to provide a foundation for explaining the behavior of gases in the atmosphere, water in the oceans and rock in the crust mantle. The content of the course includes:

- a. basic molecular properties and phase changes of solids, liquids and gases;
- b. relationships of temperature, density and pressure;
- c. convection in the atmosphere, oceans and earth mantle;
- d. plate tectonics,
- e. volcanoes, earthquakes and mountains;
- f. rock cycles, weather and fossils;
- g. planetary motion of the earth and its effect on seasons, day and night;
- h. ocean currents and coastal upwelling;
- i. solar system information;
- j. large scale movement of air masses,
- k. rain, clouds and water cycles; and
- l. weather patterns in North America.

Pathfinder

Pathfinder, A Career Decision Process, published by Interactive Video Systems, Inc., was developed to provide a low-cost system of career counseling for individuals age fifteen and older. The objectives of *Pathfinder*, are to motivate the individual to:

- a. understand how interests relate to making career decisions;
- b. identify occupations which fit his/her interests and educational goals;
- c. evaluate identified occupations; and
- d. act on career alternatives by carrying out Individual Investigation and decide on a career plan.

There are three basic components of this program: an interest inventory, a workbook, and an interactive program on videodisc. The guiding premise of the *Pathfinder* program is that there is a relationship between an individual's interests and his potential success in a given occupation. By matching these interests with those of people who have been successful in the field, it is posited that a person can make a reasonable estimate of his own satisfaction, and hence success, in that field. In order to help students identify their own interests, the first part of the program provides

the student with the Strong-Campbell Interest Inventory (SCII). Based on the interpretation of the SCII scores, the program presents the student with several occupations which are likely to be appropriate career choices and assists him to evaluate these occupations. The evaluation process is tailored to the individual based on the General Occupational Themes identified by the SCII.

Video Encyclopedia of the 20th Century

The Video Encyclopedia provides teaching material in the form of 75 hours of video materials accompanied by a "Master Index" and a four volume "Reference Set." Beginning with footage shot by Thomas Edison at the Chicago World's Fair in 1893, The Video Encyclopedia contains 2,217 units of primary source material chronicling the social, cultural and political events of the twentieth century. The films of significant events and persons contain only natural sound and speech as they were recorded, without added commentary, music or sound effects.

The print material that accompanies the encyclopedia includes the Master Index, the Video Index, and a Reference Set. The Master Index consists of a comprehensive index system featuring both an "alphabetical index" listing people, subjects and categories, as well as a separate "daily index," listing the significant events that have occurred on all 365 days of the year, extending back to 1893.

The "Videodisc Index" identifies the videodisc, disc side, and chapter number for each of the units according to the reference number contained in the "Master Index."

The "Reference Set" consists of four volumes of researched printed background material on each of 2,217 video units, including a detailed "shot list" identifying the important people and places in each scene.

Year 1 Procedures

In the fall of 1987, TVA announced that Morgan County had been selected as the site for this videodisc evaluation project and that Coalfield School would be the experimental site and that Oakdale School would serve as a contrast site. At that time all teachers in Coalfield School were brought together for a general presentation on videodisc technology and a specific introduction to the videodisc courseware that would be used in the project. Following the presentation it was made clear to all teachers that participation in the project was open to anyone who felt that the videodisc programs could be useful to them in their teaching. All teachers in the school were encouraged to participate but no one was forced to become involved if they did not wish to do so.

Equipment

Prior to the study Coalfield School had no videodisc equipment. TVA placed five Pioneer videodisc players and color monitors in the school along with one set of each of the videodisc programs described above. The videodisc equipment was distributed throughout the school in two ways. Two of the videodisc players with 13" color monitors were placed permanently in the school library along with the Video Encyclopedia of the Twentieth Century. Students would come to the library to use this program. Generally students would come to the library during study hall or during free time such as lunch. In other cases teachers would assign students to class projects and allow them time during class to research the topic. In a few instances, teachers would check out appropriate discs from the encyclopedia and use them within the classroom during class periods using the mobile disc players.

Three disc players were placed on mobile AV carts with large 25" monitors. These players could be reserved for use in the classroom throughout the day. Generally these players were in use during the entire school day and were moved from classroom to classroom between class periods. The courseware used on these mobile units was housed in the library and could be reserved and checked out for use in the classrooms. Because of the large number of teachers wishing to use the equipment and courseware scheduling became quite complex. Often teachers had to wait several weeks before the courseware that they wanted to use could be scheduled.

Teacher Training

Before teachers began using any of the videodisc materials in their classes, they were trained in the use of the videodisc medium and, specifically, in the use of *The Core Concepts* series and the *Video Encyclopedia of the Twentieth Century*. In addition, the vocational counselor serving the Coalfield School was introduced to the *Pathfinder* courseware. Training in these programs was carried out by the companies producing the materials. Training consisted of a half-day training session by each vendor. In addition to general training in the use of the videodisc medium, the vendors trained the teachers in the use of their products. During Year 1 of the project, a majority of the teachers used the courseware at some level. In cases where the didactic courseware was too difficult for younger students, teachers used the *Video Encyclopedia*. In other cases, some math and science teachers used the didactic programs quite extensively.

In addition to the initial training, a graduate student from Vanderbilt visited the school on a regular basis during the first year of the project to answer teacher questions regarding the operation

of the videodisc equipment and the courseware. Generally, there was little trouble with any of the equipment or the courseware.

Pre-Post Testing

Pre-post testing was conducted for all of the *Core Concepts* courseware. Pre-post testing was not conducted for the other videodisc packages since the other programs did not lend themselves to a pre-post paradigm. Each of the courseware packages in the Systems Impact *Core Concepts* series that was used in the project included a criterion-referenced test that covered the objectives of the program. These criterion-referenced tests served as one measure of student achievement for the study. A detailed description of each of these tests is provided under the appropriate section of this report. In addition to the criterion-referenced tests, Stanford Achievement Test measures were collected during both years of the project.

Pretest. Prior to the implementation of any of the *Core Concepts* programs, students were given the criterion-referenced test for that program. In addition, a class of the same grade and comparable ability was selected from Oakdale School to serve as a contrast and that class was also administered the criterion-referenced test at the same time.

Immediate Posttest. Immediately following the completion of each of the *Core Concepts* programs, the criterion-referenced test for that program was again administered to the class receiving the videodisc instruction and to the matched contrast class. The length of time between the pretest and posttest depended on the number of lessons in the program. The shortest program had only 15 lessons and the longest had 40. Since each lesson took one class period, the shortest period of time from pretest to posttest was approximately three weeks and the longest time was approximately two months.

Delayed Posttest. To assess the short-term retention (e.g. less than 4 months) of the material learned by the students, at the end of the first year of the project, all students at Coalfield and Oakdale who taken criterion-referenced tests during the school year were again tested. The length of time from the first to second posttest varied from one month to four months.

Log Sheets for Video Encyclopedia

To determine how the *Video Encyclopedia of the Twentieth Century* was used, teachers and students were required to log their use. The *Video Encyclopedia* was housed with other reference materials in the Coalfield School library and its use was monitored by the school librarian. The log included the name of the user, the length of time it was used, the reason for use (e.g. personal or

class assignment), and the topic that was accessed. The log sheets were returned to the librarian after each use.

Attendance and Dropout Data

Attendance and dropout data for Morgan County Schools were collected for two years prior to the project as well as during the two years of the project. These data were collected and summarized by the central office of the Morgan County Schools. Changes over this four year period will be presented in the Results section.

Year 2 Procedures

In the fall of 1988 the videodisc courseware used in Year 1 of the project was again made available to the teachers at Coalfield School. As in Year 1, the courseware was made available to any teacher wishing to use it. Again, most of the teachers used the courseware in some form during Year 2.

During Year 2, three specific studies were conducted. First, a retention study was conducted to determine how much information was retained by students from Year 1 to Year 2 in the fractions domain. Second, two application studies were conducted to determine if information learned through videodisc instruction in fractions and decimals could be applied in a word problem format. Third, a replication of several of the Year 1 pre-post studies was conducted. A description of the specific methods used for each of these studies follows.

Retention Study

To test the amount of information retained by students using the Mastering Fractions program during Year 1, the criterion-referenced instrument used as the pretest, posttest, and the delayed posttest was administered again after the summer when students had returned to their schools. A total of 22 experimental students and 30 contrast students were tested. No review was given the students prior to the test and the testing took place soon after the students returned from their summer vacation.

Application Study

The instruction presented in the *Core Concepts* series, especially in the fractions and decimals programs, is designed primarily to teach vocabulary, basic principles, and procedural knowledge. Procedural knowledge can be defined as the rules, algorithms, or procedures that include

step-by-step instructions that are to be executed in a predetermined linear sequence in order to complete specific tasks. In contrast, conceptual knowledge refers to understanding how the knowledge is useful for solving problems rather than merely following a set of algorithmic steps.

In an attempt to determine the amount of conceptual understanding that students gained with respect to the videodisc instruction, two different application tests in fractions and decimals were constructed by the project staff with help from mathematics faculty at Vanderbilt. The tests consisted of a combination of computation and word problems that required the students to understand how the knowledge they had acquired from the videodisc programs could be useful for solving the problems. These tests were given to a total of 113 experimental students and 108 contrast students. The application tests were given at the same time that the retention tests (described above) were given.

Replication Studies

To verify the effects found during the first year of the project, a series of small-scale replications of several of the Year 1 math and science studies were conducted during Year 2. All students in the replication studies, both experimental and contrast, were administered a criterion-referenced pretest in the domain of study prior to the experimental students receiving videodisc instruction. Immediately following the completion of the videodisc program all students were given criterion-referenced posttests.

RESULTS

The findings from this two year investigation will be reported by videodisc program and by year. Results from each program will be reported separately. A summary of the findings will be provided in the Discussion section.

Year 1 --Mastering Fractions

Acquisition of Procedural Knowledge

A large scale study that looked at the effects of the Mastering Fractions videodisc program on the acquisition of procedural knowledge in fractions was conducted during Year 1 of this project. As described in the Methods section, the Mastering Fractions program was used at the experimental school (Coalfield) while the regular fractions curriculum was used at the contrast school (Oakdale) during the first year of the study. The Mastering Fractions program was used for

primary instruction with 5th, 6th, 7th, and 8th grades and as a review with small consumer oriented math classes in the high school. Pretest and posttest data were collected on all grades and delayed posttest data (1 to 4 month interval) collected on grades six, seven, and eight.

The instrument used to measure student achievement was the criterion-referenced test that accompanied the Mastering Fractions program. The test consisted of 60 computation items that covered the goals of the program. This instrument was used as the pre-, post- and delayed posttest for both the experimental and contrast students. The alpha coefficients for the three administrations of the test were 0.96, 0.93 and 0.95, respectively. Table 2 shows descriptive data for the pretest, posttest, and delayed posttest for all students in the study by grade and group.

Insert Table 2 about here

To control for any differences between the experimental and contrast groups an ANCOVA analysis, using the pretest as the covariate, was conducted on the posttest scores, and when available, the delayed posttest scores. Results have been summarized in Table 3. Statistically, in every case, the experimental group had significantly higher group means on the posttest and delayed posttest when compared to the control group.

Insert Table 3 about here

Given the assumption that the instrument used to measure fractions computation knowledge is a valid one, the Mastering Fractions videodisc program appears to have been effective in producing substantial gains in the experimental students' computational ability in fractions at every grade level. Although students in the contrast group made gains, they did not make as large as gains as the experimental students who received the videodisc program.

Year 2 --Mastering Fractions

Retention Study

At the beginning of the Year 2, selected students who received the Mastering Fractions program during Year 1 were retested. A complementary set of contrast students, who had been tested in Year 1, were also retested. The instrument used for the posttest and the delayed posttest during Year 1 was again used and was administered following the summer vacation when students returned to their schools. Descriptive statistics for the students who were tested is shown in Table

4. In all cases the experimental students scored higher than the contrast students on this retention measure.

Insert Table 4 about here

An ANCOVA analysis was carried out on these data and the results are summarized in Table 5. As can be seen, at each grade level the experimental group continued to score significantly higher on this computation test than the control group when the initial pretest was used as the covariate.

From these data it appears that the gains made by the experimental students were maintained over relatively long periods without intervention. Although both groups had some degradation over this long period of time the scores on the retention tests show that the experimental group regressed less than the control group.

Insert Table 5 about here

Application Study

The ability to compute symbolic problems is one measure of mathematical ability but computation alone is an insufficient measure of conceptual mathematic understanding and does not indicate a student's ability to use math in a variety of settings. As discussed in the Methods section, a measure of student conceptual use of fractions was developed by the study team in conjunction with mathematics faculty at Vanderbilt. The test items are included in Appendix C. Some items were taken from previous studies of mathematics understanding (Lesh, Landau, & Hamilton, 1983) and allow comparison of student results to a large national sample. Item responses were summed to yield a possible score of 17. A coefficient alpha reliability calculation for the instrument yielded a value of 0.82. The test was administered just prior to the students taking the retention test at both schools. Student descriptive statistics are summarized in Table 6.

Insert Table 6 about here

As can be seen in Table 6, there is little difference between the means of experimental and contrast students on this instrument and the performance on the instrument overall is not especially good. As would be expected, however, the students' performance increased as the grade level increased. An ANCOVA was performed on these data using the pretest scores on the Mastering Fractions test as the covariate. These analyses produced no statistically significant differences

between the adjusted means for any grade level. As will be discussed more fully later, these results suggest that while the Mastering Fractions videodisc program yields effects for procedural or computational knowledge, it does not appear to yield improved performance on a measure of conceptual understanding or the applied use of fractions as measured by word problems.

Standardized Achievement Study

Data from students' permanent records were obtained for Stanford Achievement tests that are given each spring in the Morgan County School System. Normal Curve Equivalent (NCE) scores were collected for three math variables including Concept of Numbers, Math Comprehension, and Math Applications. Descriptive statistics for these three subtests are reported in Table 7.

Insert Table 7 about here

An ANCOVA analysis was undertaken on these data using the 1987 scores as the covariate. All of these analyses resulted in F ratios that were statistically significant at the .05 level with the control group having higher mean values. A further discussion of this result is found in the Discussion section.

National Comparison Study

A large scale (N=650) study conducted by (Lesh et al., 1983) provided data against which students from the current study could be compared. Three items from the applications test used in the current study came from the Lesh, et al. study. The percentage of students answering each item correctly as compared to the students of the Lesh, et al. study is shown in Table 8.

Insert Table 8 about here

The results from this comparison show that in all cases the experimental students scored below the national norm for the three items that were compared. In all cases a higher percentage of the contrast students got the three items correct than did the experimental group. Further, on one item, the contrast students scored higher than the national norm. A further discussion of these findings is provided in the Discussion section.

Replication Study

During Year 2 a smaller replication study was undertaken to test the effects noted in Year 1 for Mastering Fractions. One grade 6 class who had not received Mastering Fractions instruction during the first year of the project was selected at Coalfield School and a comparable contrast class was selected at Oakdale. The same methodology that was used during the first year study was again implemented with a pretest, posttest, and applications test being administered. Results were similar to the Year 1 study with students in the experimental group doing statistically better than the control group on the computational test ($F=31.07$, $p < .001$) but no different than the control group on the applications test ($F=1.29$, $p = .26$).

Year 1 --Mastering Decimals and Percents

Acquisition of Procedural Knowledge

A study that paralleled the first year fractions acquisition study was conducted using the Mastering Decimals and Percents videodisc program. The decimal and percent program was used at the 7th and 8th grade in the experimental school and was compared to normal classroom instruction in the contrast school. A 67 item criterion-referenced instrument that was supplied with the decimals videodisc program was used as the pre- and posttest measure. This test can be found in Appendix D. Again, alpha reliabilities of this instrument were quite high with alpha coefficients for the pretest and posttest being 0.98 and 0.96 respectively.

Descriptive statistics for the experimental and control students by grade are shown in Table 9. Due to a pretesting error (the wrong instrument was given as the pretest for some of grade 7 and all of grade 8 at the experimental school), a full ANCOVA analysis could only be done on the remaining 7th grade data. Table 10 shows that the 7th grade students who had been taught with the videodisc program made large gains in their knowledge of decimals and percents. These gains were substantially greater than those of the control group who showed little or no gain in mean decimal/percent knowledge. While a full analysis on the 8th grade data could not be run, it appears from inspection of the posttest scores that a similar result may have occurred for the experimental group.

Insert Tables 9 and 10 about here

Year 2 -- Mastering Decimals and Percents

During Year 2 a series of studies were conducted in order to collect data beyond the symbolic computation data collected during Year 1. Following is a description of the Year 2 studies.

Applications Study

As with the fractions studies in Year 2, an applications test on using decimals and percents was developed by project staff with the assistance of Vanderbilt faculty members. The test was composed of both word problems and computational problems and is found in Appendix E. The items were summed for a possible total score of 20. An alpha reliability coefficient was calculated for the test and yielded a value of .78. Students who were in the 7th grade during the 1987-88 school year took this test in the fall of the 1988-89 school year and their results are reported in Table 11.

Insert Table 11 about here

An ANCOVA with the pretest being covaried was conducted on these data and yielded a statistically significant result in favor of the experimental group ($F=18.1$, $p < .001$). It appears that the students in the experimental group were somewhat better able to apply their knowledge of decimals and percents than the contrast students. However, the very small sample size and findings from the replication study reported below raises some questions about the generalizability of this result.

Standardized Achievement Study

Stanford Achievement test data were obtained for the students involved in the study from their permanent records. Normal Curve Equivalent (NCE) scores from three subtests were analyzed: Number Concepts, Math Comprehension, and Math Applications. Table 12 lists descriptive statistics for the three math subtests.

Insert Table 12 about here

An ANCOVA with the 1987 scores being the covariate resulted in two statistically significant F ratios. For Number Concepts and Math Comprehension the control group outperformed the experimental group at the $p < .05$ level. For Math Applications there was no significant difference

between the adjusted means. These findings are consistent with the findings reported in the fractions study described above.

Replication Study

A replication of the first year decimals study was undertaken during Year 2 with one class of seventh grade students. Results were inconsistent with the Year 1 study in that the control group had higher adjusted means for both the posttest ($F=5.52$, $p=.02$) and applications ($F=41.6$, $p<.001$) tests. It is unclear as to why these results were obtained since this is the only case in the two year project where the contrast students significantly outscored the experimental students on a criterion-referenced test in a domain where the videodisc instruction took place.

Year 1 --Understanding Chemistry and Energy

The Understanding Chemistry and Energy videodisc program was used by several of the high school classes at Coalfield School. The criterion-referenced test that accompanied the program was used as the pretest and posttest for this study. Results of pretest and posttests were used to compare the students who had used the program with students from the contrast school who did not use the program but had normal classroom instruction. Descriptive statistics for the full 75 point pretest and posttest are given in Table 13. Coefficient alpha reliabilities for the total test based upon all subjects were 0.83 for the pretest and 0.98 for the posttest.

Insert Table 13 about here

Because of the diversity of classes under comparison, an overall ANCOVA was not considered to be appropriate although the differences in pre- and posttest scores is very large for the experimental group as compared to the control group. The analysis undertaken involved two steps. First, the teacher of the students at the control school was asked to review the posttest and rate the items on the test as to which of the items would have been covered by her instruction in the classes. She rated each item on a three point scale for the various classes that she taught. Items rated "1" were considered by the instructor to have been covered "a lot" in her class. Items rated "2" were covered "some" and "3" were covered "not at all". This rating was done for each subject area separately so each area had different ratings for the items.

Items that were rated "1" included questions such as "What charge does each electron have? (Item 2)" and "An atom has 2 electrons in the first set, 8 electrons in the second set, and 5

electrons in the third set. Which set is not complete? (Item 9)". Some of the items from those rated as "2" include; "How many molecules are in this picture" (Item 11) and "How many atoms are in this molecule" (Item 13) [spherical model illustrations provided for both questions].

For the biology classes, 17 items were rated "1" and 44 items were rated "2" with the balance rated "3". For physical science 28 items were rated "1" and 38 rated "2". The ANCOVA was used to analyze results in schools that offered both biology and physical science classes.

As shown in Table 14, for biology classes, when the items were rated "1", the ANCOVA resulted in a statistically significant difference in favor of the experimental treatment. Of considerable interest is that the experimental students were substantially behind the control students in prior knowledge, as noted by the large difference between pretest means. However, the experimental students surpassed the control group on the posttest.

Table 15 shows that for the items rated "2" this difference was even more pronounced among students in the experimental group who made especially large gains on these items when compared to the control group.

Insert Table 14 and 15 about here

A similar pattern of results emerged from the physical science classes. For the items rated "1", mean scores of the control group students were slightly better than the mean scores of the experimental group on the pretest but were substantially behind on the posttest. Table 16 indicates the ANCOVA and related statistics results. For items rated "2", the differences are even more pronounced as noted in Table 17.

Insert Tables 16 and 17 about here

As is indicated in the various analyses, students in the experimental group were superior to the control group on the posttest on items that the control group teacher rated as being covered "a lot" and "some" in the normal classroom instruction. Given that most of the items (51 of 75 for biology and 66 of 75 for physical science) related to the normal classroom curriculum, it appears that the use of the videodisc could substantially improve student knowledge in these areas by using the disc instead of the traditional curricular materials.

To assess retention of material learned in the video format, a delayed posttest on just those students in the experimental group was conducted. The approximate time period between the posttest and the delayed posttest was 12 weeks. Table 18 shows the means and t-tests for each

class. All t-tests were significant at the $p < .01$ level indicating a rather large decrease in mean performance after this relatively short time period. However, performance was still higher than the control group posttest scores.

Insert Table 18 about here

Year 2 -- Understanding Chemistry and Energy

Replication Study

During Year 2 a replication study was conducted with two physical science classes at the experimental school and one physical science class at the contrast school. Results were consistent with Year 1 with adjusted means of the experimental group statistically higher than the control group ($F=94.42$, $p < .001$).

Year 1 -- Earth Science

The Earth Science program was used by only one class at the experimental school. There was no attempt find a contrast class against which pre- and posttest scores could be compared. Pre- and posttests were given to the experimental students. The criterion-referenced test that accompanied the Earth Science program was used for both tests. Results from the pre- and posttest are reported in Table 19. A t-test comparing the pre and posttests resulted in significant differences in favor of the posttest scores, $t(24) = 11.84$, $p < .001$. From these data it appears that the students made significant gains in knowledge presented by the videodisc program.

Insert Table 19 about here

Year 2 --Earth Science

Replication Study

A replication of the Earth Science study described above was conducted during Year 2. As in Year 1, only students at the experimental school were included in the study. Table 20 shows descriptive statistics for pre and posttest scores on the criterion-referenced test that accompanied the

Earth Science program. The results of the t-test indicate that the gains made from the pretest to the posttest were significant, $t(48) = 18.94, p < .001$. The results were consistent with the year one study.

Insert Table 20 about here

Pathfinder

The *Pathfinder* career decision process program was used by the guidance counselor at the Coalfield school on such a limited basis there was insufficient opportunity to determine if the program was effective in helping students to make career decisions. Several reasons can be posited for the low use of the *Pathfinder* program. First, the *Pathfinder* program was a more complex program than the others in that it was a level 3 interactive program, requiring that a computer be used in addition to the videodisc. Second, the counselor had little to no computer experience prior to the study. Three, the counselor received neither computer training nor *Pathfinder* training prior to the study. Given this combination of variables it is not surprising that little use was made of the program.

Year 1 Video Encyclopedia Use by Teachers and Students

Teachers across all grade levels reported using the Video Encyclopedia of the Twentieth Century. The discs were used in a variety of classes and in a number of different ways. A summary from the reports collected from teachers and students follows.

Teacher Use in Classes

Clearly one of the segments most used was on the civil rights movement of the 1960s. For example, six of the elementary teachers used the video to aid in classroom discussions of civil rights and of the assassination of Martin Luther King, Jr. by James Earl Ray. This topic appeared to be of particular interest to the students in Coalfield because James Earl Ray is currently housed in Brushy Mountain State Prison which is located near the school.

Video segments most used by elementary teachers discussed holidays and other special events. A number of teachers of young children reported using the segment on Groundhog Day. Other popular topics at the elementary level were Valentine's Day, Presidents, Mt. Rushmore, World War 2, Early aircraft, and the Space Shuttle.

At the junior high and high school level, teachers used the encyclopedia in more interactive ways. In one English class, the students used the videodisc to make presentations to the class. The students suggested this approach as an alternative to writing a journal. The French class incorporated excerpts from the video encyclopedia into a videotaped "news program" and presented them in class and at the curriculum fair. The speech teacher used the disc to illustrate different styles of speeches and different types of speakers, and regional dialects. This teacher also required students to use the video encyclopedia as one of their sources to write a research paper. Finally, the teacher in the sociology class used the material on Charles Manson to discuss breaking norms in society and the sanctions that follow.

These are but a few of the uses that were made of the video encyclopedia. A discussion of how the encyclopedia could be used in conjunction with the didactic videodisc programs described above will occur in the discussion section that follows.

Student Use

During the first year of the project the videodisc checkout forms for students who used the discs in the library numbered 908. Of these, 750 of the forms were for the Video Encyclopedia discs. The topics used by students varied considerably with over 350 different topic numbers being chosen by students as their first choice of topic to view. Content of topics most chosen included entertainment areas such as football bowl games and animal segments but also included historical events important to the students such as James Early Ray's escape and the killing of John Lennon. Average time of use of all discs was approximately 23 minutes and the average rating of usefulness of the disc by students was 3.67 on a 5 point scale with 1 being "not helpful at all" to 5 being "extremely helpful". Reasons for use of the disc were split about 2/3 "personal interest topic" vs. 1/3 "class assignment".

Data on the use of the Video Encyclopedia were not collected during Year 2. Record keeping procedures required for collecting these data taxed the library staff and therefore could not be justified by the project staff.

Attendance and Dropout Study

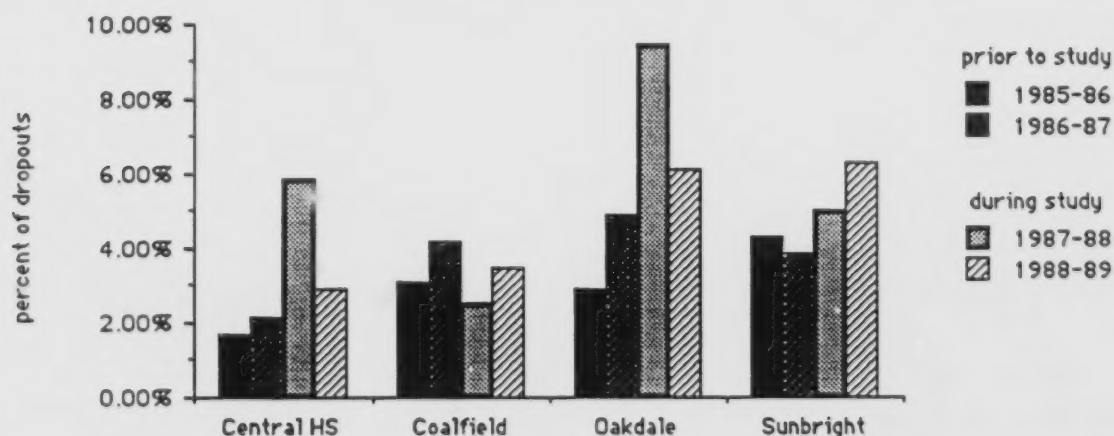
Attendance and dropout data were collected for the two years prior to this project as well as during the two years it was conducted. These data were collected in an attempt to determine if the videodisc programs placed in Coalfield School would have a positive effect on attendance and at the same time reduce the number of students dropping out of school. Although many variables

affect attendance and dropout figures, Table 21 shows that Coalfield School had the highest attendance rate in the Morgan County School System during the two years of the project with an average of more than 95% attendance during those years. During the two years prior to the study Coalfield, ranked second and fourth, respectively.

 Insert Table 21 about here

Dropout data were much more difficult to monitor than attendance. Often when a student would leave a school it was difficult to determine whether or not that student would attend another school outside of the county. The data shown in Figure 2 show the percent of students who dropped out of the four county high schools for the project period and the two years prior to that. As can be seen in the graph, during the first year of the project, 1987-88, Coalfield clearly had the lowest number of dropouts in the entire school system. Although the percent of students dropping out went up slightly during the second year, the number was still quite good in comparison to the other schools. Although it is impossible to draw cause and effect relationships from these data, it is possible that the videodisc intervention did have some effect on the students with respect to encouraging them to remain in school.

Figure 2. A comparison of the percent of students dropping out of school prior to, and during, the project period.



DISCUSSION

We believe that the findings from this two-year project are both exciting and alarming. Exciting from the point of view of the potential that the videodisc medium offers learners. Alarming from the point of view that much of the knowledge learned by students in this study was not learned in a form that could be transferred to problem-solving situations. In the remainder of this section we will review the results from this project and discuss them with respect to some of the current literature in learning and cognition. We will close with a discussion of how the information learned from this project can possibly help make all of America's students better thinkers and problem solvers.

Clearly, the findings from the studies that examined student learning in the content domains of fractions, decimals, and percents raises some interesting questions about the effectiveness of the Mastering Fractions and Mastering Decimals and Percents videodisc programs. The criterion-referenced pretest and posttest data from both programs suggest that the videodisc instruction is effective in teaching procedural knowledge. Further, it appears that students who receive this instruction retain this information over relatively long periods of time. For example, as shown in Figure 3, the experimental students consistently scored higher over time than the contrast students on the criterion-referenced measures of fractions. One could conclude from these findings that the videodisc programs facilitated acquisition and retention of procedural knowledge.

Although procedural knowledge seemed to be acquired and retained by the experimental students, some of the other findings suggest that this knowledge by itself was not very useful for these students. For example, as shown in Figure 4, data from the fractions application and retention studies suggest that even though the experimental students scored higher than the contrast students on the criterion-referenced retention test of fractions, they did no better than the contrast students on the fractions applications test. In fact, neither the experimental nor the contrast students were successful on the applications test. These findings suggest that neither set of students were able to transfer spontaneously their knowledge of fractions to applications where this knowledge could be used.

Figure 3. Comparison of pretest, posttest, delayed posttest, and retention scores for experimental and contrast students on fractions.

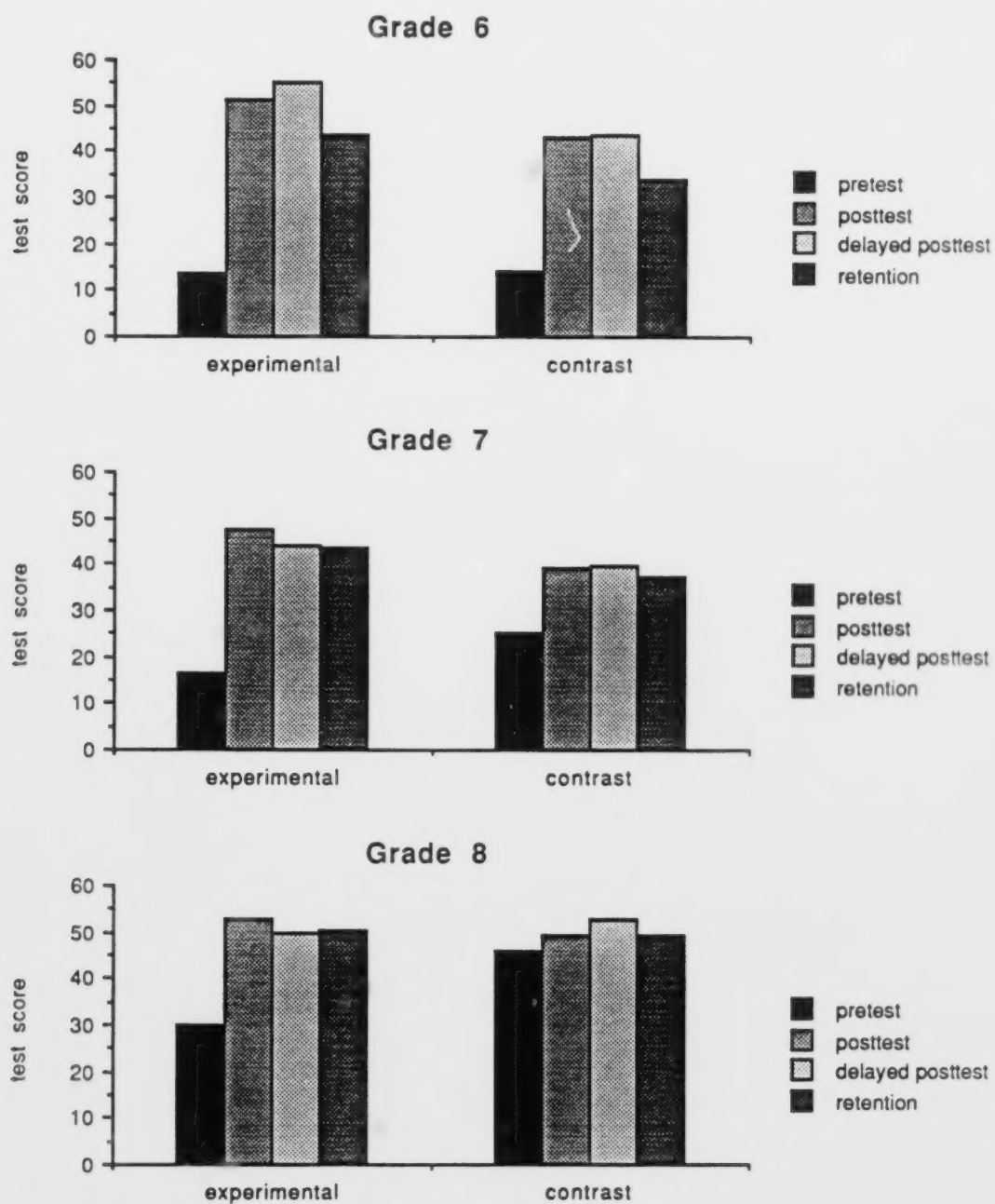
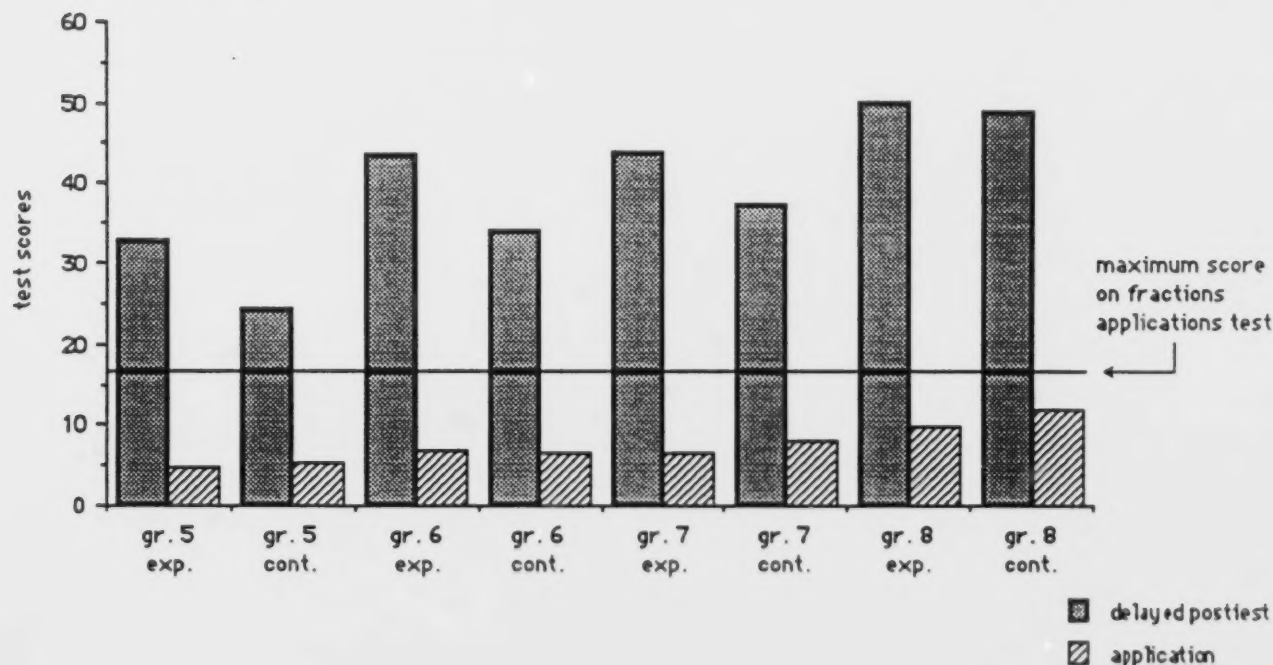


Figure 4. Comparison of fractions application and replication test scores for experimental and contrast students.



Additionally, gains made by experimental students on the criterion-referenced tests measuring procedural knowledge of fractions and decimals did not transfer to standardized measures. Actually, this should not be surprising. It is unlikely that gains in fractions and decimals computation skills alone would show up on standardized scores since these tests cover a large number of concepts. It should be noted that in the standardized achievement study the contrast students significantly outscored the experimental students on all but one measure. Again, this should not be surprising given that the contrast students outscored the experimental students on all of the math pretest measures used in this study. Clearly, the contrast students came to this project with better math skills than the experimental students. However, in both the fractions studies and the decimals and percent studies, the videodisc programs brought the experimental students to higher levels of procedural skills than the contrast students as measured by the criterion-referenced tests used in the project. This

demonstrates the powerful effect that the videodisc programs had on developing math knowledge in the experimental students.

The findings from the studies on chemistry and energy are similar to those of the math studies. In terms of learning the information that was tested, the experimental students scored significantly higher than did the contrast students even when we attempted to control for test bias. Clearly, the videodisc program had a powerful effect on teaching the science knowledge measured by the criterion-referenced tests. Unfortunately, it appears that this knowledge was quite unstable in that the short-term retention study showed that a significant amount of the information was lost after only 12 weeks.

With respect to these findings it appears that the videodisc programs in math and science were effective for teaching procedural skills and knowledge but what was learned was often unstable and inert. That is, the information was learned as facts and not as tools and in the math area the students did not spontaneously understand how this information could be useful to them in problem solving situations where it would have to be applied.

We believe that the math and science videodisc programs evaluated in this project provide the student with an excellent start but that the programs simply do not take the student to the point that the information becomes useful. This is not to say that the programs do not do what they are intended to do. To the contrary, the findings from this project suggest that after completing the programs the students do in fact have a great deal of knowledge. The problem is that this knowledge remains inert if students are not shown how this information can be useful to them in their everyday world.

Overcoming the Inert Knowledge Problem

One response to the inert knowledge problem has been to develop problem solving contexts that enhance learning and transfer (CTG, 1990). At the heart of this model is an emphasis on creating an anchor or focus that generates interest and enables students to identify and define problems and to pay attention to their own perception and comprehension of these problems. They can then be introduced to information that is relevant to their anchored perceptions. The major goal of anchored instruction is to enable students to notice critical features of problem situations and to experience the changes in their perception and understanding of the anchor as they view the situation from new points of view.

Anchored instruction begins with a focal event or problem situation that provides an anchor for students' perceptions and comprehension. Ideally, the anchor will be intrinsically interesting and will enable students to deal with a general goal (e.g., planning a trip or

improving the efficiency of a business) that involves a variety of related subproblems and subgoals. Effective anchors should also help students notice the features of problem situations that make particular actions relevant. For example, imagine creating a general problem-solving context that always requires the calculation of the perimeter of areas of land. Students could learn to perform well in this context yet fail to differentiate the conditions that require information about perimeters from those that require information about the area of various land segments. In order to appropriately conditionalize their knowledge, the anchors for instruction must help students focus on the relevant features of the problems that they are trying to solve.

Case-based approaches to instruction historically have provided one illustration of anchored instruction. They have been used in business and law schools for many of the reasons that were discussed earlier. In 1940, Gragg lamented that traditional forms of instruction failed to prepare business students for action. The students knew a lot of facts and concepts but failed to use them to make effective business decisions. In case-based approaches, students first begin with cases that represent problems-to-be-solved. As they are introduced to new concepts and frames for thinking, they see the effects of this information on the problems they confront.

Programs such as Lipman's (1985) "Philosophy for Children" and Wales and Stager's (1977) "Guided Design" are also excellent illustrations of anchored instruction. Lipman's program is centered around novels involving children who encounter a number of problems in their everyday lives and at school. They learn to use a variety of methods from philosophy for exploring these problems. In "Guided Design," students are introduced to interesting problems plus a general framework for solving problems. Students generate their own strategies for solving the problems and then work with others to develop a group consensus. Each group's solution is then compared to the strategies used by experts in particular domains.

In these programs, the focal events or anchors are almost always presented in a verbal format. This format is fine for a number of purposes. However, there are also advantages of providing video-based anchors rather than relying on a purely verbal mode.

Video anchors. One advantage of using video-based anchors is that they contain much richer sources of information than are available in the printed media. Gestures, affective states, scenes of towns, music, and so on can accompany the dialogue. Therefore, there is much more to notice than is true for books. This increase in opportunities for noticing is especially important for increasing the possibility of finding relevant issues that are embedded in the video -- it provides an opportunity to encourage problem finding and problem representation (e.g., Bransford & Stein, 1984) rather than to always provide preset problems to students. In addition, the richness of information to be noticed increases the opportunity to help students

appreciate how their perception and comprehension change as they are helped to view the video from multiple points of view.

A second advantage of using video-based anchors is closely related to the first. Often, the ability to perceive dynamic, moving events facilitates comprehension. Young children may need to see waves and strong winds in order to deeply understand these concepts; older students may be helped by viewing moving scenes that illustrate acceleration versus constant velocity. Johnson (1987) provided a powerful illustration of the advantages of video versus purely verbal forms of information transmission. He worked with young 4- and 5-year-old students from the inner city who teachers felt were at risk for school failure because of a lack of language skills and other preschool experiences. Some of the students were instructed in a verbal format; others were instructed in the context of video stored on videodiscs. The video-based instruction resulted in much greater retelling scores and comprehension scores than did the instruction that was conducted in verbal form.

The advantages of using video are enhanced by the capabilities of videodisc technology. In this format, each of the 54,000 frames that make up the 30 minutes of video on one side of a disc has a unique number and can be located in seconds (compared to the extremely slow and cumbersome methods of access available on videotape). Frames can be played in slow motion or frozen clearly for detailed study so that students can take advantage of this rich source of information, or the video can be scanned rapidly looking for important events (these features were previously available on only the most expensive videotape players). This ease of access to any part of the video changes its function, from a linear element used to introduce or enhance instruction to an integral resource that can be explored and analyzed in detail. Teachers can locate and replay scenes in order to illustrate particular points or to invite class discussion. Segments of video that are not contiguous can be easily juxtaposed and contrasted to develop pattern recognition skills. This type of access can be accomplished using only a videodisc player and a simple hand-held remote control device, an inexpensive system comparable in price to an ordinary videotape player.

Summary

In summary, it is our belief that the findings from this two-year investigation support the need for multiple teaching strategies. Clearly the didactic videodisc programs that were used in this project were useful for teaching students basic facts and procedures in math and science. It was also made clear from these studies that students must be taught to use this knowledge in meaningful ways if it is to be helpful to them in solving real-world problems. Recent research

on "anchored instruction" suggests that the videodisc medium can be a powerful tool for creating learning environments where students can learn to apply procedural knowledge to real-world problems. In many instances, it would be possible to use video scenes from the Video Encyclopedia of the 21st Century as anchors for a variety of subject areas. We believe that by providing teachers and students with a combination of didactic and anchored forms of video instruction we can begin to develop technology-based instructional programs that can have a positive and powerful effect on student thinking and problem solving.

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TABLES

Table 1**Demographics of Schools in Morgan County**

School Name	Grades	Number Teachers	Number Students
Central Elementary	K-8	43	953
Central High	9-12	20	453
Coalfield	K-12	25	516
Oakdale	K-12	24	549
Petros Joyner Elem.	K-8	11	205
Sunbright	K12	33	716

Table 2

Year 1 -- Descriptive Statistics for Mastering Fractions Pre-, Post- and Delayed Posttest Scores**Pretest**

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
GRADE 5			
Experimental	6.72	4.04	25
Control	10.48	6.12	31
GRADE 6			
Experimental	13.52	6.97	36
Control	13.93	7.97	32
GRADE 7			
Experimental	16.21	12.77	28
Control	25.40	12.22	25
GRADE 8			
Experimental	30.02	12.09	40
Control	45.85	8.45	28
GRADE 11			
Experimental	37.00	0.00	1
GRADE 12			
Experimental	40.16	12.62	6
GRADE 10-12			
Control	38.91	8.87	12

Table 2: Continued

Posttest

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
GRADE 5			
Experimental	53.08	6.92	25
Control	36.87	10.85	31
GRADE 6			
Experimental	51.05	7.13	36
Control	43.15	10.61	32
GRADE 7			
Experimental	47.50	10.65	28
Control	39.28	9.75	25
GRADE 8			
Experimental	52.65	8.08	40
Control	49.57	7.72	28
GRADE 11			
Experimental	58.00	.00	1
GRADE 12			
Experimental	58.16	3.54	6
GRADE 10-12			
Control	50.08	3.31	12

Delayed Posttest

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
GRADE 5			
Experimental	53.66	10.27	24
GRADE 6			
Experimental	55.29	7.44	34
Control	43.62	11.53	32
GRADE 7			
Experimental	43.92	10.47	26
Control	39.75	13.35	20
GRADE 8			
Experimental	49.97	9.29	40
Control	52.77	7.15	27

Table 3

Year 1 -- Summary ANCOVA for Fractions Procedural Knowledge Acquisition

<u>Grade</u>	<u>Post with Pre F</u>	<u>Sig. of F</u>	<u>DPost with Pre F</u>	<u>Sig. of F</u>
5	81.75	$p < .001$	Not Tested	
6	17.52	$p < .001$	34.19	$p < .001$
7	34.58	$p < .001$	8.34	$p < .006$
8	37.23	$p < .001$	9.15	$p < .004$
H.S.	35.96	$p < .001$	Not Tested	

Table 4

Year 2 -- Descriptive Statistics for Mastering Fractions Retention Test

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
<u>Grade 5</u>			
Experimental	33.09	10.39	22
Control	24.23	11.64	30
<u>Grade 6</u>			
Experimental	43.57	9.82	28
Control	34.08	9.08	25
<u>Grade 7</u>			
Experimental	43.96	10.65	25
Control	37.34	12.68	23
<u>Grade 8</u>			
Experimental	50.26	7.23	30
Control	49.19	9.71	26

Table 5

Year 1 -- Summary ANCOVA for Mastering Fractions Posttest Scores

<u>Grade</u>	<u>F Value Fall Delayed Post</u>	<u>Sig. of F</u>
5	23.27	p < .001
6	21.52	p < .001
7	23.53	p < .001
8	14.68	p < .001

Table 6

Year 2 -- Descriptive Statistics for Mastering Fractions Applications Test

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
<u>Grade 5</u>			
Experimental	4.72	2.49	22
Control	5.30	3.20	30
<u>Grade 6</u>			
Experimental	6.86	3.82	29
Control	6.58	3.16	29
<u>Grade 7</u>			
Experimental	6.66	3.90	27
Control	8.08	4.28	23
<u>Grade 8</u>			
Experimental	9.82	3.12	35
Control	12.00	3.13	26

Table 7

Year 2 -- Descriptive Statistics for Mastering Fractions Achievement DataSummaries of Number Concepts 87

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	69.11	23.44	136
Control	71.98	19.87	128

Summaries of Number Concepts 88

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	57.50	22.17	136
Control	69.64	18.90	128

Summaries of Math Comprehension 87

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	66.62	23.77	136
Control	72.79	20.49	128

Summaries of Math Comprehension 88

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	54.75	22.77	136
Control	68.10	21.88	128

Summaries of Math Applications 87

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	66.17	24.15	136
Control	70.13	20.66	128

Summaries of Math Applications 88

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	57.01	21.63	136
Control	63.96	19.98	128

Table 8

Year 2 -- Student Performances on Selected Items of Fractions Application
Test as Compared to a National Sample

<u>Test Item 13</u>	<u>Project % Correct</u>	<u>National % Correct</u>
Grade 5		25
Experimental	18	
Control	33	
Grade 6		39
Experimental	28	
Control	34	
 <u>Test Item 14</u>	 <u>Project % Correct</u>	 <u>National % Correct</u>
Grade 5		34
Experimental	32	
Control	43	
Grade 6		45
Experimental	28	
Control	59	
 <u>Test Item 15</u>	 <u>Project % Correct</u>	 <u>National % Correct</u>
Grade 5		60
Experimental	55	
Control	57	
Grade 6		73
Experimental	65	
Control	62	

Table 9

Year 1 -- Descriptive Statistics for Mastering Decimals and Percents Pretest and Posttest ScoresPretest

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
GRADE 7			
Experimental	10.48	9.45	31
Control	36.00	15.48	24
GRADE 8			
Control	47.88	10.66	27

Posttest

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
GRADE 7			
Experimental	39.85	16.31	41
Control	34.58	17.03	24
GRADE 8			
Experimental	52.85	9.04	41
Control	52.33	13.24	27

Table 10

Year 1 -- Summary ANCOVA for Mastering Decimals and Percents Posttest Scores

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates					
PRETOT	3447.60	1	3447.60	32.23	.000
Main Effects					
GROUP	3028.16	1	3028.16	28.31	.000
Explained	6475.76	2	3237.88	30.271	.000
Residual	5562.16	52	106.96		
Total	12037.92	54	222.92		

Multiple Classification Analysis

Grand Mean = 33.964

Variable + Category		Unadjusted		Adjusted for Independents		Adjusted for Independents + Covariates	
	N	Dev'n	Eta	Dev'n	Beta	Dev'n	Beta
GROUP							
Experimental	31	-.48		9.40			
Control	24	.62		-12.14			
			.04				.72
Multiple R Squared							.538
Multiple R							.733

Table 11

Year 2 -- Descriptive Statistics for Mastering Decimals and Percents Applications Test

	<u>Raw Mean</u>	<u>Adj. Mean</u>	<u>N</u>
<u>Grade 7</u>			
Experimental	7.46	9.99	26
Control	8.39	4.74	18

Table 12

Year 2 -- Descriptive Statistics for Mastering Decimals and Percents Achievement DataNumber Concepts 1987

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	69.81	22.05	82
Control	65.21	19.77	51

Number Concepts 1988

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	50.01	19.15	82
Control	65.99	16.98	51

Math Comprehension 1987

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	66.66	22.43	82
Control	67.67	19.17	51

Math Comprehension 1988

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	52.88	19.74	82
Control	61.95	20.56	51

Math Application 1987

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	63.40	24.61	82
Control	61.76	19.09	51

Math Application 1988

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Experimental	52.52	20.54	82
Control	57.42	16.56	51

Table 13

Year 1 -- Descriptive Statistics for Understanding Chemistry and Energy
Pretest and Posttest ScoresPretest

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Control - Gen. Sci.	24.16	3.82	18
Control - Bio I	23.93	3.57	15
Control - Phy. Sci.	17.10	5.23	29
Experimental - Phy. Sci	14.52	3.09	25
Experimental - Bio I	14.86	4.27	22
Experimental - Bio I	18.81	4.91	11
Experimental - Phy. Sci	9.38	4.53	21
Control - Bio II	30.62	5.2355	8
Control - Chem	29.33	5.8949	9

Posttest

	<u>Mean</u>	<u>Std Dev</u>	<u>N</u>
Control - Gen. Sci.	23.83	4.44	18
Control - Bio I	26.86	4.91	15
Control - Phy. Sci.	23.31	6.23	29
Experimental - Phy. Sci	67.56	7.03	25
Experimental - Bio I	61.36	8.24	22
Experimental - Bio I	67.72	5.34	11
Experimental - Phy. Sci	63.47	9.19	21
Control - Bio II	34.50	8.51	8
Control - Chem	31.66	4.63	9

Table 14

Year 1 -- Means and ANCOVA for Items Rated "1" - Biology ClassesPre- and Posttest Means for Items Rated "1" - Biology Classes

<u>Group</u>	<u>Pre- Mean</u>	<u>Pre S.D.</u>	<u>Post- Mean</u>	<u>Post- S.D.</u>	<u>N</u>
Experimental	6.61	2.03	15.91	1.26	33
Control	11.96	2.53	13.52	2.94	23

Analysis of Covariance - Posttest by Group with Pretest

<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>DF</u>	<u>Mean Square</u>	<u>E</u>	<u>Signif of F</u>
Covariates					
Pretest	3.87	1	3.87	.991	.324
Main Effects					
Group	106.56	1	106.56	27.24	.000
Explained	110.43	2	55.21	14.11	.000
Residual	207.27	53	3.91		
Total	317.71	55	5.77		

Grand Mean = 14.929

<u>Variable + Category</u>	<u>N</u>	<u>Unadjusted Dev'n</u>	<u>Eta</u>	<u>Adjusted for Independents Dev'n</u>	<u>Beta</u>	<u>Adjusted for Independents + Covariates Dev'n</u>	<u>Beta</u>
SCHOOL							
Experimental	33	.98		1.60			
Control	23	-1.41		-2.30			
			.49			.81	
Multiple R Squared						.348	
Multiple R						.590	

Table 15

Year 1 -- Means and ANCOVA for Items Rated "2" - Biology Classes

<u>Group</u>	<u>Pre- Mean</u>	<u>Pre S.D.</u>	<u>Post- Mean</u>	<u>Post- S.D.</u>	<u>N</u>
Experimental	8.73	2.78	36.88	5.65	33
Control	12.91	3.09	14.43	4.63	23

Analysis of Covariance - Posttest by Group with Pretest

<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>DF</u>	<u>Mean Square</u>	<u>E</u>	<u>Signif of F</u>
Covariates					
Pretest	1218.6	1	1218.60	52.98	.000
Main Effects					
Group	5883.0	1	5883.03	255.80	.000
Explained	7101.63	2	3550.81	154.39	.000
Residual	1218.91	53	22.998		
Total	8320.55	55	151.283		

Multiple Classification Analysis

Grand Mean = 27.66

<u>Variable + Category</u>	<u>N</u>	<u>Unadjusted Dev'n</u>	<u>Eta</u>	<u>Adjusted for Independents Dev'n</u>	<u>Beta</u>	<u>Adjusted for Independents + Covariates Dev'n</u>	<u>Beta</u>
SCHOOL							
Experimental	33	9.22				10.55	
Control	23	-13.23				-15.14	
			.91				1.04
Multiple R Squared							.854
Multiple R							.924

Table 16

Year 1 --Means and ANCOVA for Items Rated "1" - Physical Science ClassesPre- and Posttest Means for Items Rated "1" - Physical Science Classes

<u>Group</u>	<u>Pre- Mean</u>	<u>Pre S.D.</u>	<u>Post- Mean</u>	<u>Post- S.D.</u>	<u>N</u>
Experimental	6.00	3.16	26.17	2.38	46
Control	9.79	3.98	14.52	4.09	29

Analysis of Covariance - Posttest by Group with Pretest

<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>DF</u>	<u>Mean Square</u>	<u>E</u>	<u>Signif of F</u>
Covariates					
Pretest	113.86	1	113.86	15.736	.000
Main Effects					
Group	2505.83	1	2505.83	346.31	.000
Explained	2619.69	2	1309.84	181.02	.000
Residual	520.97	72	7.236		
Total	3140.66	74	42.441		

Multiple Classification Analysis

Grand Mean = 21.66

<u>Variable + Category</u>	<u>N</u>	<u>Unadjusted Dev'n</u>	<u>Eta</u>	<u>Adjusted for Independents Dev'n</u>	<u>Beta</u>	<u>Adjusted for Independents + Covariates Dev'n</u>	<u>Beta</u>
SCHOOL							
Experimental	46	4.51				5.21	
Control	29	-7.15				-8.26	
			.88				1.01
Multiple R Squared							.834
Multiple R							.913

Table 17

Year 1 -- Means and ANCOVA for Items Rated "2" - Physical Science ClassesPre- and Posttest Means for Items Rated "2" - Physical Science Classes

<u>Group</u>	<u>Pre- Mean</u>	<u>Pre S.D.</u>	<u>Post- Mean</u>	<u>Post- S.D.</u>	<u>N</u>
Experimental	6.59	2.36	33.13	5.00	46
Control	8.21	2.68	9.52	3.34	29

Analysis of Covariance - Posttest by Group with Pretest

<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>DF</u>	<u>Mean Square</u>	<u>E</u>	<u>Signif of F</u>
Covariates					
Pretest	233.22	1	233.22	14.18	.000
Main Effects					
Group	9939.18	1	9939.18	604.61	.000
Explained	10172.40	2	5086.20	309.40	.000
Residual	1183.59	72	16.439		
Total	11356.00	74	153.459		

Multiple Classification Analysis

Grand Mean = 24.00				Adjusted for	
<u>Variable + Category</u>	<u>N</u>	<u>Unadjusted Dev'n</u>	<u>Eta</u>	<u>Adjusted for Independents Dev'n</u>	<u>Independents + Covariates Beta</u>
SCHOOL					
Experimental	46	9.13		9.60	
Control	29	-14.48		-15.23	
			.93		.98
Multiple R Squared					.89
Multiple R					.94

Table 18

Year 1 -- Means and t-tests for Posttest to Delayed Posttest on Understanding Chemistry and Energy

Class	Posttest		Delayed Posttest		N	t	Sig. 1
	Mean	S.D.	Mean	S.D.			
Phy. Sci - 4	68.04	6.75	49.21	9.54	24	17.1	<.001
Phy. Sci - 7	64.53	6.28	41.00	7.98	19	16.2	<.001
Bio. I - 5	60.75	8.34	49.60	10.92	20	7.82	<.001
Bio. I - 6	67.80	5.63	50.50	5.25	10	8.40	<.001

Table 19

Year 1 -- Pre and Posttest Descriptive Data for Earth Science

Group	Mean	Std Dev	N
Pretest	21.38	7.81	24
Posttest	46.13	11.41	24

Table 20

Year 2 -- Pre and Posttest Descriptive Data for Earth Science

Group	Mean	Std Dev	N
Pretest	24.94	6.28	48
Posttest	49.71	10.73	48

Table 21

Rank Order for Attendance in Morgan County Schools

School	1985-86	1986-87	1987-88	1988-89
Central Elementary	6	7	5	4
Central High	3	3	7	6
Coalfield	2	4	1	1
Lancing	5	1	3	-
Oakdale	1	2	2	2
Petros Joyner Elem.	7	5	4	5
Sunbright	4	6	6	3

Appendices

- A. An Overview of Videodisc Technology
- B. Criterion-Referenced Test -- Fractions
- C. Applications Test -- Fractions
- D. Criterion-Referenced Test -- Decimals and Percents
- E. Applications Test -- Decimals and Percents
- F. Criterion-Referenced Test -- Chemistry and Energy
- G. Criterion-Referenced Test -- Earth Science

Appendix A
An Overview of Videodisc Technology

Appendix A

An Overview of Videodisc Technology

A stand alone, optical scan, videodisc system consists of a videodisc player, a color monitor, and a prerecorded videodisc. The videodisc player uses a low-powered laser beam to scan and decode the video and audio information that is stored on the surface of the disc.

Today's videodisc systems are optical systems which allows the reading of information from the disc without physical contact, thereby eliminating wear on the disc. The videodisc resembles a shiny metallic long-playing record album without visible grooves. The disc rotates in the player at the speed of 1800 rpm. The videodisc player uses a laser beam to read the information stored on the disc. As the disc rotates, a low-powered laser is directed onto the disc surface and the intensity of the laser light is modulated by billions of microscopic pits etched on the disc surface. As the light is reflected off of the surface a sensor transforms the modulated light into visual signals that are then displayed on the video monitor.

A videodisc can store the same information as a videotape, but the disc is a random access medium. Information can be stored in each of the 54,000 individual frames found on each side of a videodisc. This capacity is equivalent to 675 trays of 35 mm slides, or a 1/2 hour motion picture film. The player can randomly access any information on the disc in about three seconds or less. Information can take several forms. For example, movies, still pictures, or text can be placed on a videodisc medium.

The videodisc is an extremely durable and robust medium. The surface of the disc is coated with a thin clear plastic to protect it from dirt and scratches. Since nothing except the laser light touches the disc surface during information retrieval, the disc does not wear out. The optical disc player supports such advanced features as random frame access, freeze frame, reverse, variable speeds, stereo sound, and can be programmed to operate with a computer.

Levels of Interactivity

A classification system that describes the level of interactivity of various videodisc configurations was proposed by the Nebraska Videodisc Design and Production Group in 1979 (Daynes, 1984). This classification system is based on the "interactive" levels of different systems. This classification scheme includes Levels 0 through 3. They are as follows:

Level 0 - This system consists of a linear player. Designed primarily for home entertainment, the system has limited interactive functions.

Level 1 - The features of a Level 1 player include quick frame access, freeze frame and scanning functions, two user selectable audio channels and chapter and picture stops. These features are controlled manually through a remote control device, thus allowing the user to stop the disc, scan forward or backward, jump to specific frames, and to freeze images. For a more complete description of the features included in a Level 1 videodisc system, the reader is referred to Hoffmeister, Englemann, and Carmine (1986).

Level 2 - The Level 2 player is equipped with an internal microprocessor that adds intelligence to the Level 1 functions. The computer program that controls the presentation resides on the disc audio track and is loaded from the disc to the microprocessor. The user indicates answers to questions or makes choices through the remote control device used for controlling the disc player. The player responds by branching to different disc segments depending upon the logic of the computer program. This level of interaction is limited by the amount of memory in the microprocessor and by the fact that the computer program cannot be altered once it has been placed on the disc.

Level 3 - Systems at this level consist of a Level 1 or Level 2 player linked to a microcomputer. This configuration allows both computer and videodisc-generated material to be shown on the screen. Branching is controlled by computer software. Because the presentation is driven by the microcomputer, a variety of input devices including the computer keyboard, joystick, light pen, and touch screen, can be used. Additionally, responses can be recorded using the computer's external storage devices.

Appendix B

Criterion-Referenced Test -- Fractions

Mastering Fractions Mastery Test

Start time _____
Finish time _____
Total time _____

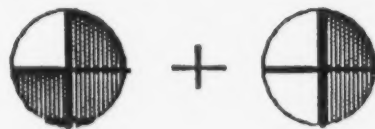
Name _____
Date _____

☐ Pretest
☐ Posttest

Teacher _____
School _____

A. Write the fraction for each picture and the total.

1.



 =

2.



 =

B. Circle the correct answer.

1. $\frac{4}{5}$ more than one
equals one
less than one

2. $\frac{5}{1}$ more than one
equals one
less than one

3. $\frac{6}{6}$ more than one
equals one
less than one

C. Multiply and write the answer.

1. (2) $\frac{3}{5} =$

2. $\frac{3}{5} \times \frac{3}{1} =$

3. $\frac{3}{4} \times \frac{4}{2} =$

D. Follow the directions for each part below.

a. Write the missing numbers.

1. $\frac{5}{6} () = \frac{\square}{18}$

2. $\frac{\square}{2} () = \frac{6}{12}$

3. $\frac{2}{3} () = \frac{\square}{21}$

4. $\frac{4}{\square} () = \frac{16}{20}$

b. Write the missing whole numbers.

1. $\frac{4}{4} = \square$

2. $\square = \frac{7}{1}$

3. $\square = \frac{200}{1}$

c. Circle each fraction that equals 3.

1. $\frac{3}{1}$

2. $\frac{12}{4}$

3. $\frac{3}{9}$

d. Complete each equation.

1. $\frac{5}{8} = 1$
 $\square$

2. $\frac{2}{5} = \frac{2}{5}$
 $\square$

3. $1 = \frac{600}{\square}$

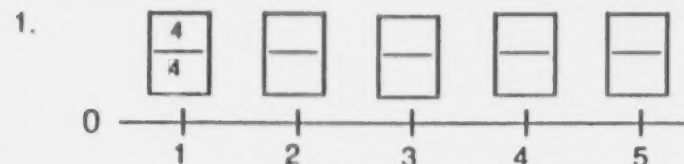
e. Fill in the boxes.

1. $2 = \frac{\square}{7}$

2. $\frac{\square}{3} = 9$

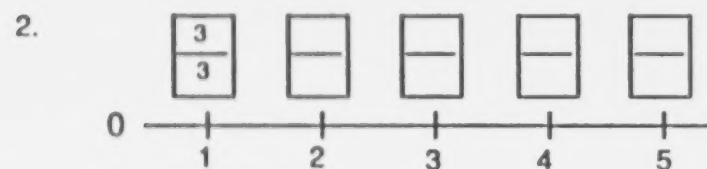
3. $4 = \frac{\square}{6}$

E. Follow the directions for each of the number line problems.



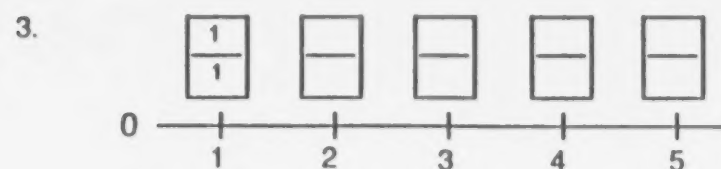
Fill in the boxes with the fractions for the whole numbers.

Put an X on the number line where the fraction $\frac{6}{4}$ should be



Fill in the boxes with the fractions for the whole numbers.

Put an X on the number line where the fraction $\frac{5}{3}$ should be



Fill in the boxes with the fractions for the whole numbers.

Put an X on the number line where the fraction $\frac{5}{1}$ should be

F. Fill in the boxes with the correct number.

1. Write the first common number for 9 and 7.

2. Write the first common number for 2, 10, and 4.

3. Write the first common number for 8 and 2.

G. Follow the directions for each part below.

a. Write the first common number for the denominators.

1. $\frac{1}{2}$

2.

3.

$$\frac{1}{4}$$

$$\frac{3}{4}$$

$$\frac{2}{5}$$

$$\frac{5}{6}$$

$$\frac{1}{8}$$

$$\frac{2}{7}$$

b. Work each problem that can be worked the way it is written.

1.

$$\frac{3}{4}$$

$$\frac{7}{8}$$

$$\frac{7}{4}$$

$$+\frac{5}{3}$$

$$-\frac{3}{8}$$

$$-\frac{7}{5}$$

c. Work each problem.

1.

2.

3.

$$\frac{3}{4}$$

$$4$$

$$\frac{6}{5}$$

$$+\frac{2}{3}$$

$$-\frac{2}{3}$$

$$+\frac{1}{5}$$

d. Work each problem.

1.

2.

3.

$$\frac{1}{3}$$

$$3$$

$$\frac{2}{5}$$

$$\frac{3}{4}$$

$$\frac{1}{2}$$

$$\frac{1}{2}$$

$$+\frac{1}{2}$$

$$+\frac{1}{4}$$

$$+\frac{3}{10}$$

H. Follow the directions for each part below.

a. Write each fraction as a division problem, then write the mixed number that it equals.

1. $\frac{31}{3}$

2. $\frac{27}{10}$

3. $\frac{29}{4}$

b. Simplify these fractions.

1. $\frac{12}{28}$

2. $\frac{8}{10}$

3. $\frac{15}{40}$

I. Write each mixed number as a fraction.

1. $1 \frac{3}{5}$

2. $7 \frac{2}{3}$

3. $4 \frac{1}{6}$

J. Work the problems.

1. $\frac{4}{5} \div \frac{1}{4} = \boxed{}$

2. $5 \div \frac{3}{7} = \boxed{}$

3. $\frac{3}{7} \div \frac{3}{2} = \boxed{}$

K. Work each problems. Simplify each answer if you can.
Write each answer as a mixed number if you can.

1. $3 - \frac{3}{4} =$

2. $\frac{3}{8} \div \frac{1}{2} =$

3. $\frac{5}{9} - \frac{1}{2} =$

4. $4 \times 1\frac{5}{6} =$

5. $2\frac{1}{3} + 1\frac{4}{5} =$

6. $\frac{3}{4} + 1\frac{1}{2} + 2 =$

Appendix C

Applications Test -- Fractions

TVA Project: Fractions Application Test Draft Version 3 8/17/88

Name _____

Grade _____

Teacher _____

Date _____

1. $\frac{3}{4}$ of 100 people in a survey liked soft drink X better than they liked soft drink Y.

How many people liked soft drink X better? _____

2. Twelve out of 36 students went to the football game on Friday night.

What is the simplest fraction that represents the fraction of students that went to the game? _____

3. One board was $6\frac{5}{8}$ inches long and the other was $2\frac{3}{4}$ inches long.

How long would the two boards be together? _____

4. Four friends were going to divide up 3 chocolate bars. Each of the bars can be divided easily into 4 equal pieces.

How many of these pieces would each friend get? _____

5. Suppose the friends in the last question had 5 chocolate bars to divide. How many whole bars and how many pieces would each friend get?

whole bars _____ pieces _____

Write the number of whole bars and pieces as a mixed number. _____

6. Mr Jones is going to bake a cake. The recipe calls for $\frac{1}{2}$ cup of sugar. Mr. Jones only has a $\frac{3}{4}$ cup measuring cup.

What fraction of the $\frac{3}{4}$ cup should he fill in order to get $\frac{1}{2}$ cup?

7. Sandy is buying hamburger meat at the grocery store. She buys $5\frac{1}{4}$ pounds of hamburger meat. How many $\frac{3}{8}$ pound hamburgers can she make?

8. Simplify the following fraction

$$\frac{12}{32}$$

9. Work the following problem. Write your answer as a mixed number.

$$2\frac{7}{8} + 5\frac{1}{4} =$$

10. Work the following problems.

a. $\frac{2}{3} \times 60 =$

b. $\frac{4}{7} \times 7 =$

11. Change the following fraction to a mixed number

$$\frac{8}{7} =$$

12. What is the missing fraction that must be used in the problem below.

$$\frac{5}{8} \times \underline{\quad} = \frac{1}{2}$$

Circle the correct answer for the questions below.

13. What does $\frac{3}{4}$ of 12 equal?

a. $\frac{48}{3}$ b. $12 \frac{3}{4}$ c. 9 d. 3 e. not given

14. Sue is $2 \frac{1}{2}$ years old. Her brother Tim is $6 \frac{1}{2}$ years older than Sue. How old is Tim?

a. 4 b. 8 c. 9 d. $6 \frac{1}{2}$ e. not given

15. Which picture shows $\frac{2}{3}$ shaded?

a.



b.



c.



d.



e. not given

Appendix D

Criterion-Referenced Test -- Decimals and Percents

Mastering Decimals and Percents Mastery Test

Name _____

Date _____

☐ Pretest

☐ Posttest

Teacher _____

School _____

Start Time	_____
Finish Time	_____
Total Time	_____

A. Follow the directions for each part below.

a.

1. Circle the number 8 and 5 tenths.

8.05 85.0 8.5

2. Circle the number 12 and 7 thousandths.

12.700 12.007 12.070

3. Circle the number 6 and 15 hundredths.

6.15 6.015 615.00

b.

1. Rewrite 18 as a decimal number with hundredths. _____

2. Rewrite 4.5 as a decimal number with thousandths. _____

3. Rewrite 8.700 as a decimal number with tenths. _____

B. Follow the directions for each part below.

a. Write the missing value for each row.

	Fractions	Decimals
1.	$\frac{5}{100}$	
2.		.45
3.		2.3
4.	$\frac{5}{1000}$	
5.	$\frac{20}{100}$	
6.		7.50

b. Write the fraction and the whole number each percent equals.

1. $400\% = \frac{\boxed{}}{\boxed{}} = \boxed{}$
2. $800\% = \frac{\boxed{}}{\boxed{}} = \boxed{}$
3. $100\% = \frac{\boxed{}}{\boxed{}} = \boxed{}$

c. Fill in the missing values for each row.

	Decimals	Fractions	Percents
1.	1.34		
2.		$\frac{5}{100}$	
3.			300%
4.	.27		
5.			96%
6.			298%
7.		$\frac{17}{100}$	
8.		$\frac{600}{100}$	
9.			153%
10.	.01		

C. Work the problems.

1. $5 - .69 =$

2. $18.76 - .054 =$

3. $9 - 8.076 =$

4. $4 + 3.97 + 11 + .098 =$

~~5. 9.000 =~~ OMIT

6. $6 + .058 + 1.98 =$

D. Work the problems.

1. 2.4×1.1

2. $.053 \times 1.5$

3. $.147 \times .03$

4. $1.07 \times .008$

E. Put in the decimal points and zeros and work the problems.

a.

1. $4 \overline{) 9}$

2. $5 \overline{) 8}$

3. $2 \overline{) 9}$

b.

1. $6 \overline{) 5}$

2. $4 \overline{) 3}$

3. $8 \overline{) 4}$

c.

1. $12 \overline{) .3}$

2. $4 \overline{) .1}$

3. $8 \overline{) .5}$

d.

1. $.25 \overline{) 3}$

2. $.04 \overline{) 6}$

3. $.12 \overline{) 9}$

e.

1. $.12 \overline{) 54}$

2. $.04 \overline{) 20}$

3. $.24 \overline{) 120}$

f. Change the fraction to a decimal.

1.

$$\frac{1}{8} = \boxed{}$$

2.

$$\frac{30}{40} = \boxed{}$$

3.

$$\frac{6}{24} = \boxed{}$$

g. Change the mixed number to a decimal.

1.

$$3 \frac{5}{8} = \boxed{}$$

2.

$$1 \frac{1}{10} = \boxed{}$$

3.

$$7 \frac{4}{5} = \boxed{}$$

F. Follow the directions for each part below.

a. Divide these problems until you have four decimal places. Mark the repeating part.

1.

$$.6 \overline{) 1}$$

2.

$$11 \overline{) 3}$$

3.

$$15 \overline{) 4}$$

b. Round these decimal numbers to the nearest tenth.

1.

$$.491 = \boxed{}$$

2.

$$.817 = \boxed{}$$

3.

$$21.34 = \boxed{}$$

c. Round these decimal numbers to the nearest hundredth.

1.

$$.099 = \boxed{}$$

2.

$$.963 = \boxed{}$$

3.

$$5.186 = \boxed{}$$

G. Write each equation with a decimal number and figure out the answer.

1. 115% of 30 is what number?

2. 8% of 12 is what number?

3. 90% of 32 is what number?

Appendix E

Applications Test -- Decimals and Percents

TVA Project Decimals and Percents Applications Test Second Draft 8/10/88

Name _____

Grade _____

Teacher _____

Date _____

1. A bank pays 6.5% interest per year on money that is deposited in an account.

If a person deposits \$100 in the bank and leaves in the for one year how much money will the person earn in interest? _____

2. Old Spanish coins were sometimes called "Pieces of Eight" because they were sometimes broken into eight pieces to be used for smaller coins.

What percent of a coin would a person have if they had one of these eight pieces? _____

What is the decimal number that would represent this percentage? _____

3. Four nephews inherited \$84,000 from their rich uncle and the will stated that they must split the money equally.

What percentage would each nephew receive? _____

What would be the actual amount of money that each nephew would receive? _____

4. The sales tax in many parts of Tennessee is 6.0%.

What is this percentage in terms of a decimal? _____

What is this percentage in terms of a fraction of 100? _____

5. Stocks in companies on the stock market sometimes are priced in fractions like $6 \frac{3}{8}$ per share.

What would be the price of this stock in a decimal? _____

6. Jim and Jill collected some aluminum cans to be recycled. Jim collected 15.42 pounds and Jill collected 16.4 pounds.

How many pounds did they collect together? _____

If they got five cents for each pound, how much money did each of them get (to the nearest penny)? Jim: _____ Jill: _____

7. Fill in the missing values for the following.

percent	decimal	fraction
9.0%	_____	_____

8. Change the mixed number to a decimal.

$$7 \frac{5}{8} =$$

9. Change the fraction to a decimal.

$$\frac{1}{5} =$$

10. Work the following problems

8.4% of 1,000 is what number? _____

40% of 42,000 is what number? _____

$$13.26 + 18.5 = \underline{\hspace{2cm}}$$

$$.04 \times 12.55 = \underline{\hspace{2cm}}$$

$$11.5 \times .08 = \underline{\hspace{2cm}}$$

Appendix F

Criterion-Referenced Test -- Chemistry and Energy

Understanding Chemistry and Energy

Mastery Test

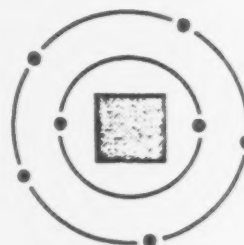
Student _____
 Date _____
 Teacher _____
 School _____

Start time	_____
Finish time	_____
Total time	_____

Part A1

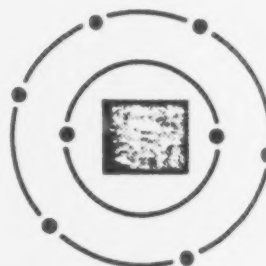
1. What charge does each proton have? _____
2. What charge does each electron have? _____
3. What charge does each neutron have? _____

4. This picture shows the _____s of an atom.



Part A2

1. If this atom has no overall charge, how many positive charges does it need? _____
2. Atom A has 20 protons. Atom b has 21 protons. Could they be atoms of the same element? _____
3. We know that an atom has 15 neutrons. Can we tell what kind of atom it is? _____

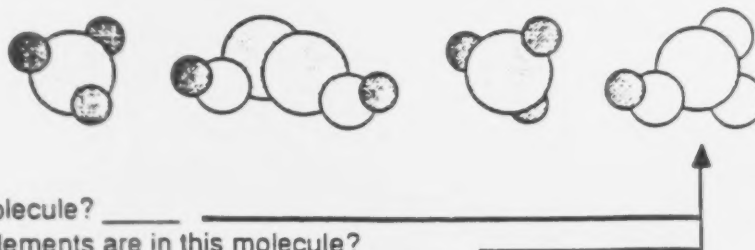


Part A3

1. In an atom, the first complete set of electrons contains _____ electrons.
2. An atom has 2 electrons in the first set, 8 electrons in the second set, and 5 electrons in the third set. Which set is not complete? _____
3. How many more electrons are needed to make that set complete? _____

Part B1

1. How many molecules are in this picture? _____
2. How many different chemical compounds are there? _____
3. How many atoms are in this molecule? _____
4. How many different chemical elements are in this molecule? _____



Part C1

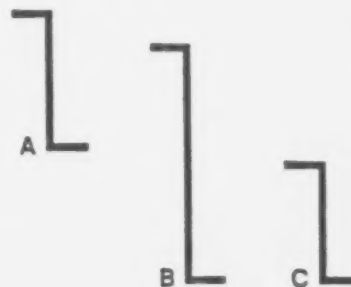
1. Energy is the _____.
2. List the 5 common forms of energy. _____

Part C2

1. Energy in one form can be converted _____.
2. Which form of energy is a by product of all other forms? _____

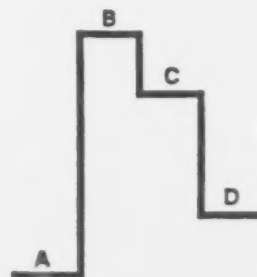
Part D1

1. Which reaction requires the least amount of energy to go uphill? _____
2. Which reaction releases the greatest amount of energy when it goes downhill? _____
3. Which reaction has higher-energy chemicals with the least amount of stored energy? _____



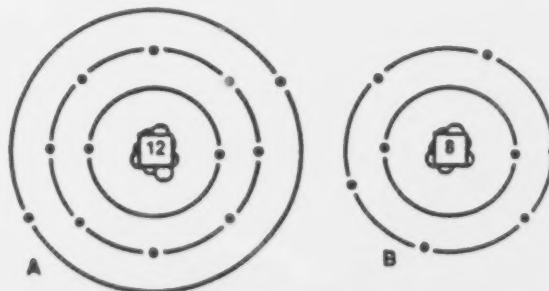
Part D2

1. Which letter shows where the largest percent of chemicals will be at equilibrium? _____
2. Which letter shows where the smallest percent of chemicals will be at equilibrium? _____



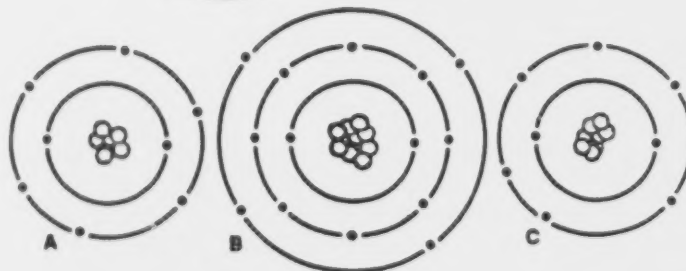
Part E1

1. These atoms will bond ionically.
Which atom will lose electrons? _____
2. How many electrons will it lose? _____



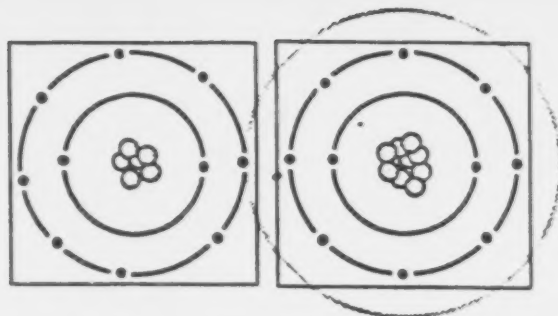
Part E2

1. When these atoms bond covalently, how many pairs of electrons will atom A share? _____
2. How many pairs of electrons will atom B share? _____

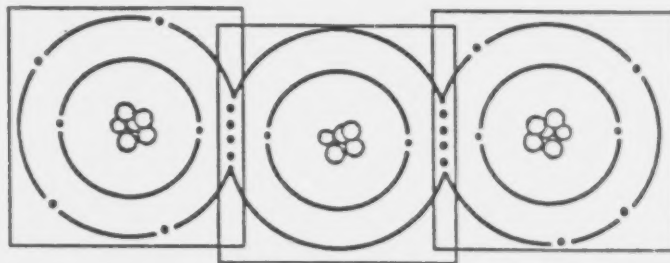


Part E3

1. The box is drawn for each atom in this compound. What kind of bond is shown? _____



2. The box is drawn for each atom in this compound. What kind of bond is shown? _____

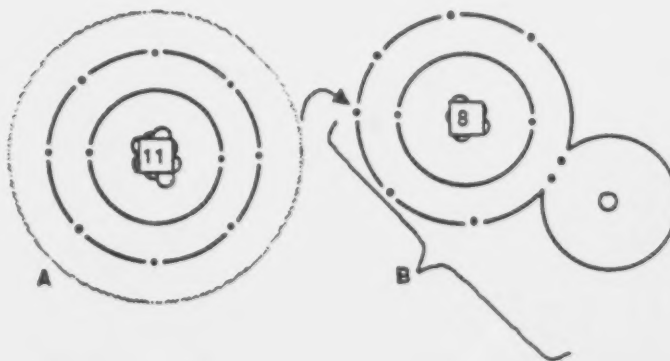


Part E4

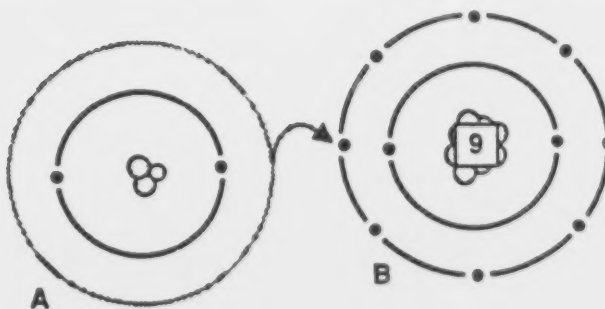
1. For bonds to form, atoms _____
2. Bonds form faster _____

Part F1

1. The arrow shows where an electron moved. A is a _____ ion.



2. The overall charge of atom B is _____



Part G1

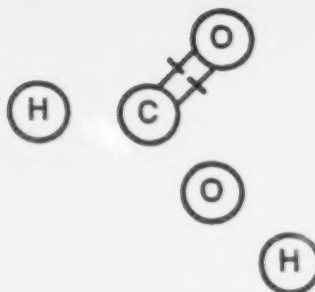
1. List the primary elements used in organic compounds.

Part G2

1. Which element is in all organic compounds? _____
2. In organic compounds, nearly all bonds are _____

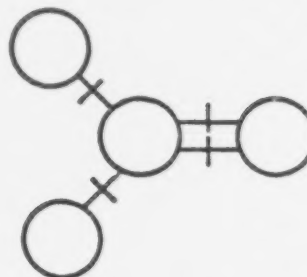
Part G3

1. Complete the bonds in this organic molecule.



Part G4

1. Write the chemical symbol inside each atom of this organic molecule.



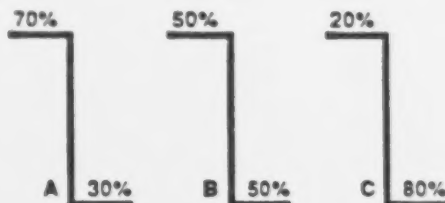
Part G5

1. List each organic compound, the chemical elements it uses and what it is used for.

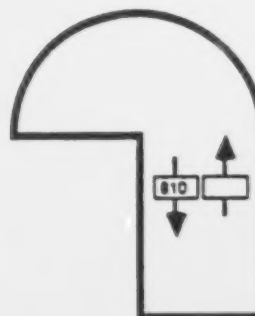
_____	fats, oils, waxes	_____	used for _____
_____	sugars, starches	_____	used for _____
_____	chains of amino acids	_____	used for _____
_____	DNA, RNA	_____	gives instructions for _____

Part H1

1. Write the letter of each reaction that could be at equilibrium. _____



2. If this reaction is at equilibrium, what number should be showing on the "up" counter? _____



- All reactions go towards _____.
- Each chemical reaction has its own _____.
- The larger the difference in energy levels, the larger the percent of _____ at equilibrium.

Part H2

These reactions are at equilibrium.
The percentages of lower-energy chemicals are: 55%, 75%, 90%.

1. Which reaction will have 55% of the chemicals on the lower-energy level? _____
2. Which reaction will have 75% of the chemicals on the lower-energy level? _____



Part I1

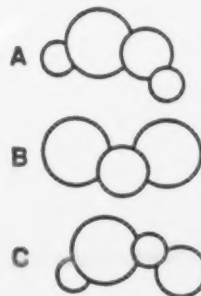
1. Which reaction has the largest energy of activation? _____
2. Which reaction will reach equilibrium first? _____
3. Which reaction requires the largest amount of energy to get started? _____
4. Which of these reactions is more likely to keep going downhill after it gets started? _____



Part I2

1. A catalyst lowers the _____.
2. A catalyst speeds the reaction in _____.
3. A catalyst is not _____ by the reaction.

4. Which molecule will fit this catalyst? _____

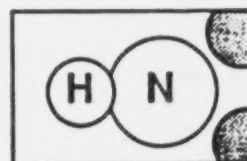


Part J1

1. Water allows dissolved chemicals to _____ and _____.
2. The formula for water is _____.
3. All biological systems have a _____.
4. Water _____ than any other common substance.
5. Many _____ and many molecules with _____ or _____ bonds dissolve well in water.

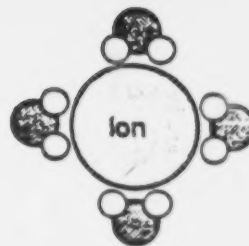
Part J2

1. Here is an N-H bond in a molecule. Which end of a water molecule will be attracted to the N atom, the H end or the O end? _____



Part J2 (cont)

2. Here are some water molecules surrounding an ion.
Which end of the water molecules is attracted to the ion, the positive end or the negative end? _____

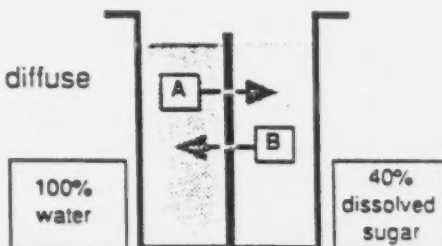


Part K1

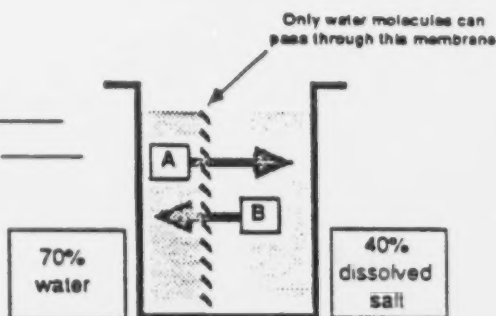
1. Diffusion is movement from _____ to _____.
2. _____ of molecules causes _____.
3. Diffusion is faster in _____.
4. Diffusion is slower in _____.

Part K2

1. Which arrow shows the direction that the sugar will diffuse when the barrier is removed? _____

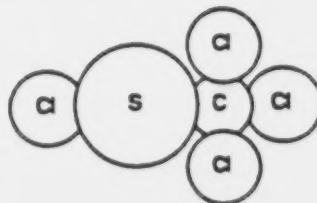


2. What is the percentage of water on side B? _____
3. On which side will the level of the liquid rise? _____

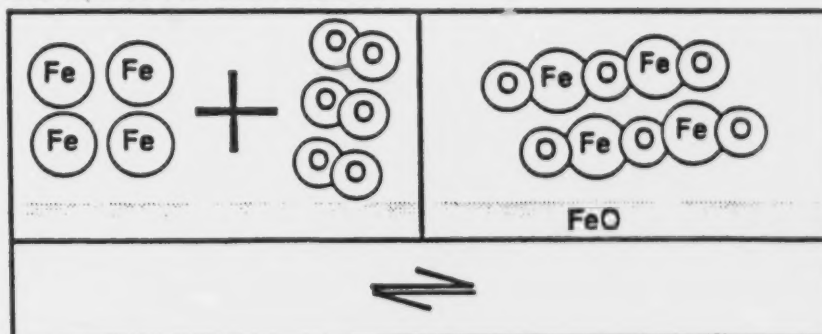


Part L

1. Write the formula for this compound.
Write the elements in this order: N, H, O.



2. Write the entire equation for this reaction.



Appendix G

Criterion-Referenced Test -- Earth Science

Earth Science Mastery Test

Name _____
Date _____

☐ Pretest
☐ Posttest

Start time _____
Finish time _____
Total time _____

Teacher _____
School _____

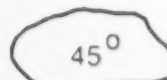
The temperatures are shown on the rocks.

1. Which rock has the fastest-moving molecules? _____

2. Which rock has the slowest-moving molecules? _____



A



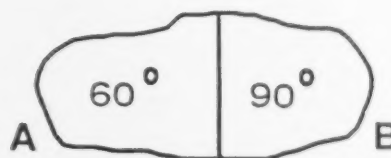
B



C

The temperatures of substances A and B are shown.

3. What will happen to the temperature of B?



4. What is this process called? _____

Object A is easier to move in outer space than object B.

5. Which object has more mass? _____

6. Which object would weigh more on earth? _____

We increase the mass of a substance but the volume stays the same.

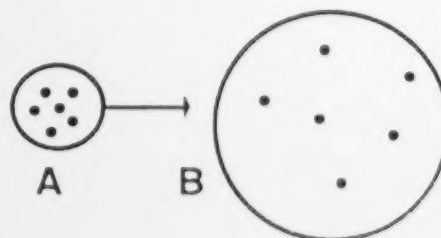
7. Are there more molecules or fewer molecules in volume? _____

8. Does the density increase or decrease? _____

An object changed from size A to size B.

9. Did it expand or did it contract? _____

10. Did the density increase or did it decrease? _____



A blob and a medium are the same density. We heat the blob.

11. What happens to the speed of the molecules in the blob? _____

A blob and a medium are the same density. We heat the blob.

12. What happens to the size of the blob? _____

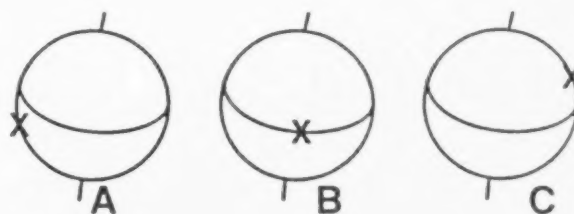
13. What will the blob do in the medium? _____

14. If the earth were not tilted, there would be no _____.

15. When it is summer in the Northern Hemisphere, what season is it in the Southern Hemisphere? _____

16. During winter in the Northern Hemisphere, is the most direct sunlight above the equator or below the equator? _____

17. Each X shows where the most direct sunlight is striking the earth. Which letter shows spring or fall? _____



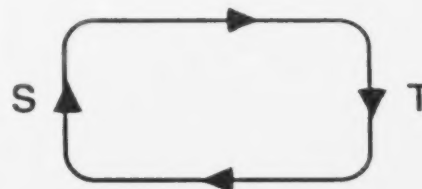
18. The wind is blowing this flag. Which is the area of high pressure, A or B? _____



19. The arrow shows the direction these blobs move in a medium. Which letter shows the area of low pressure? _____



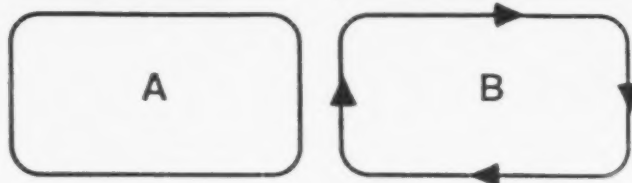
20. Write the letter for the side of this convection cell that is less dense. _____



21. Write H to show each area of high pressure and L to show each area of low pressure.



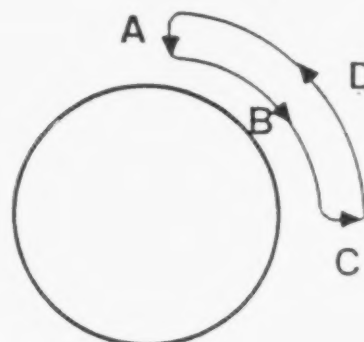
22. A and B are a pair of convection cells. Draw the arrows in A to show the movement of the blobs.



Here's a picture of convection in the atmosphere. The earth is not rotating.

23. Which letter is closest to the equator? ____

24. Which letter is closest to the North Pole? ____

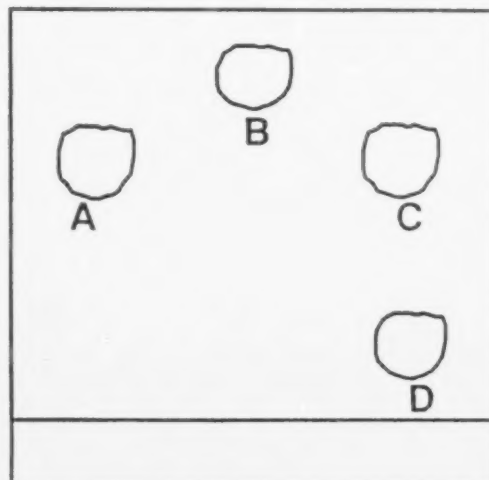


Here are three blobs in the atmosphere. The blobs are not moving.

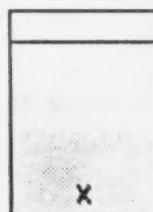
25. Which blob has the most pressure on it? ____

26. Which two blobs have the same amount of pressure on them? ____

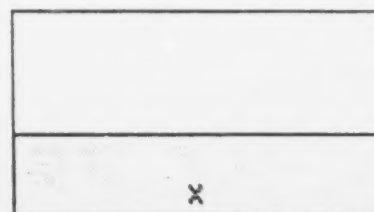
27. If blob B moved up, how would the pressure on the blob change?
- _____



28. Where is the pressure on X greater, in tank R or tank S?
- _____



R



S

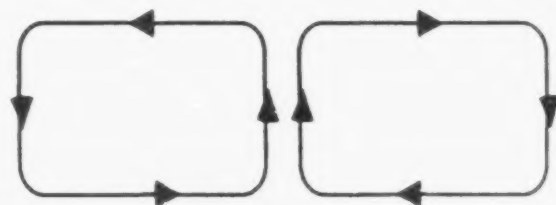
29. The same static pressure is on two blobs. One blob is in air and one blob is in water. Which column above the blob would be higher, the column of air or the column of water? ____
- _____

30. How many total atmospheres of pressure are on an object that is 10 feet under rock? ____
31. How far under the ocean's surface would an object have to be to have a total of 3 atmospheres of pressure on it? ____

The pressure on two blobs is the same. One blob is in sea water. One blob is in fresh water.

32. Which water is more dense? ____
33. Which column above the blob is higher, the sea water or the fresh water? ____
34. Where is granite formed, at mid-ocean ridges or at subduction zones? ____

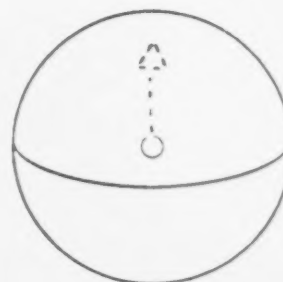
35. Are these convection cells pulling the crust apart or pushing it together?



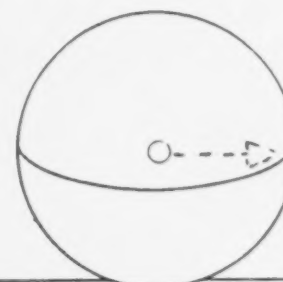
36. Is this pattern of convection cells found at a mid-ocean ridge or at a subduction zone?

37. What kind of rock is formed at mid-ocean ridges? ____

38. This earth is rotating.
The dotted arrow shows the direction the air starts to move.
Draw an arrow to show the path the air takes.



39. This earth is rotating.
The dotted arrow shows the direction the air starts to move.
Draw an arrow to show the path the air takes.

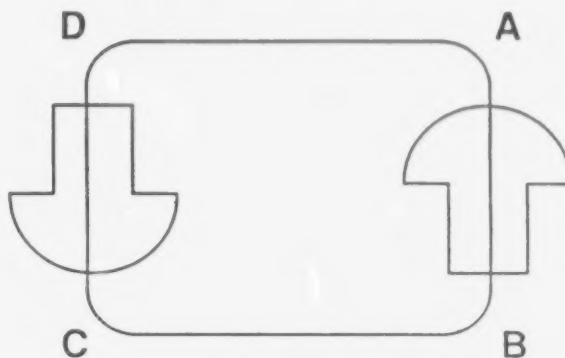


This diagram shows ocean convection.

40. Which letter shows where the surface water is the coldest? _____

41. Which letter shows where the surface water would be higher? _____

42. Draw an arrow to show the movement of blobs along the BOTTOM of the convection cell.



43. Which weathering force dissolves rocks? _____

44. Which weathering force cracks rocks by making them expand and contract? _____

45. Which carrier deposits material of different sizes in the same place? _____

46. Which two carriers deposit materials of different sizes in different places? _____

47. Here's a stream.
At which letter are the smallest particles deposited? _____

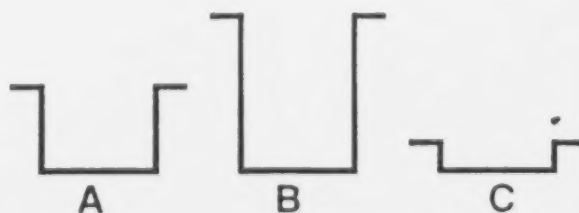


An air mass rises from the surface to 7,000 feet.

48. Where is it colder, at the surface or at 7,000 feet? _____

49. Where can the air hold more water vapor, at the surface or at 7,000 feet? _____

50. The containers show how much water an air mass can hold at different temperatures. Which container shows the hottest air? _____



51. An air mass is holding all the water it can hold. The air mass cools. How much water can it hold now—more water, or less water?
- _____

52. Write the letters in the order that shows the water cycle.

The first letter is C.

- A. Water evaporates.
 - B. Streams return water to ocean.
 - C. The sun heats the earth.
 - D. Water vapor forms clouds.
 - E. Rising air cools.
 - F. Rain falls.
- _____

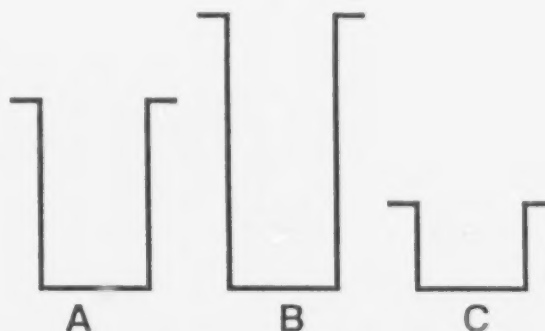
These containers show the relative humidity of three air masses.

53. Which air mass has the lowest relative humidity? _____

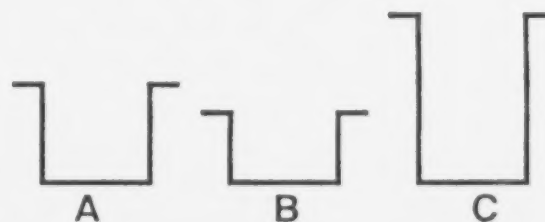
54. Which air mass has the highest relative humidity? _____

55. Which air mass is the coldest? _____

56. Which air mass is the hottest? _____



57. Container A represents the amount of water vapor an air mass can hold at 40°. Which container shows the same air mass at 70°? _____



58. The temperature of an air mass changes. The relative humidity goes from 30% to 80%. Was the air mass heated or cooled? _____

59. Two air masses are the same size. They both have a relative humidity of 70%. Air mass A is 40°. Air mass B is 80°. Which air mass is holding more water vapor? _____

After each name, write I if it is an igneous rock. Write S if it is a sedimentary rock. Write M if it is a metamorphic rock.

60. Sandstone _____
 61. Slate _____
 62. Limestone _____
 63. Basalt _____
 64. Quartzite _____

65. Is this a young stream valley, an old stream valley, or a glacial valley?



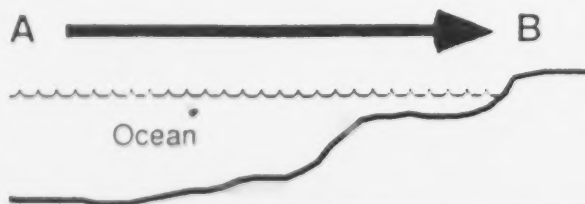
66. Is this a young stream valley, an old stream valley, or a glacial valley?



67. On which boundary of the ocean does water pile up? _____
 68. On which boundary of the ocean does coastal upwelling occur? _____
 69. When coastal upwelling stops, the process is called _____.
 70. If the equatorial currents weaken, what happens to the upwelling? _____
 71. In the winter, which cools faster, the oceans or the continents? _____
 72. In summer, where is the air rising, over the oceans or over the continents? _____

Here is a picture of a surface wind.

73. Where is the air rising?

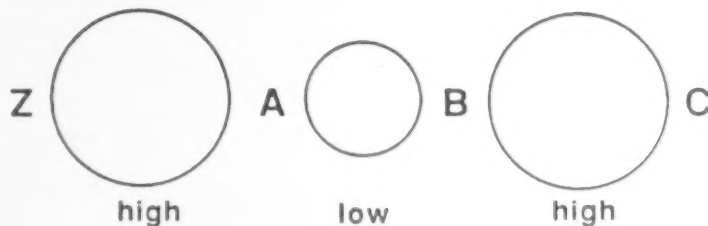


74. What are the three primary air masses that affect North America? _____

75. Air moving out from a high in the Northern Hemisphere forms the letter ____.

76. Here are highs and lows moving across North America.

If you were at A, would the air come from the north
or from the south? _____



77. How many low tides are there every 24 hours? _____

78. Write the letter of each place that has a high tide. _____

